THE NATURAL AND CHEMICAL ELEMENTS OF AGRICULTURE.

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OF

AGRICULTURE.

TRANSLATED FROM THE LATIN OF

COUNT GUSTAVUS [illegible] GYLLENBORG,

By JOHN MILLS, Esq; F. R. S.

Member of the Royal Society of Agriculture at Paris and Rouen, of the Oeconomical Society of Berne, and of the Palatine Academy of Sciences at Belles-Lettres.

Non ex facis ofprimare, Patres melior homini, ex ingluvie

[illegible] Prim. Ju. Pars.

LONDON:

Printed for JOHN BELL, near Exeter-Change, in the Strand, and C. ETHERINGTON at York.

M.DCC.LXX.

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TO

THE RIGHT HONOURABLE

WILLS EARL OF HILLSBOROUGH,

VISCOUNT KILWARLIN OF THE KINGDOM OF IRELAND,

AND BARON HARWICH OF GREAT BRITAIN,

ONE OF HIS MAJESTY'S PRINCIPAL SECRETARIES OF STATE,

FIRST LORD COMMISSIONER FOR TRADE AND PLANTATIONS,

AND ONE OF HIS MAJESTY'S MOST HONOURABLE PRIVY COUNCIL.

F. R. S. F. R. S.

MY LORD,

THE intrinsic merit of Count Gyllenborg's Treatie, of which the following sheets are a translation, will, I am confident, obtain Your Lordship's approbation

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My Lord,

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tion

tion of my endeavours to render ſo excellent a work generally known and beneficial to my countrymen. I therefore have only to aſk Your pardon, for ſeeking your Lordſhip's patronage. Your unwearied application, My Lord, to national objects, Your aſſiduity in promoting, and abilities in conducting them, are convincing proofs, that the ſmalleſt attempts of this ſort are not beneath Your notice, nor, permit me to ſay, below Your protection. You, My Lord, who preſide in the commercial department of this country, are too ſenſible of the mutual ſupport between Trade

and

and Agriculture, not to countenance the one, while you direct the other. They are sister-arts, on which the wealth and power of a nation are founded, and by which alone that wealth and power can be maintained.

But it was not to Your Lordship, as a Statesman only, that I proposed to myself the honour of addressing this treatise. When I considered Your Lordship, even in Your short recess from public business, as dedicating and ennobling it by Your instruction, encouragement, and example in cultivating lands, improving the arts

of huſbandry, and, in fact, rendering barren waſtes ſubſervient to the uſes and conveniencies of Your fellow-creatures; I was naturally induced to wiſh for the permiſſion of prefixing Your Lordſhip's name to theſe ELEMENTS OF AGRICULTURE, and the more ſo, as they were firſt written by a Nobleman, who, like You, My Lord, makes it his ſtudy to promote the happineſs of mankind.

I am,

with profound reſpect,

MY LORD,

YOUR LORDSHIP'S

moſt obedient

humble ſervant,

JOHN MILLS.

WHITEHALL,
October 10th, 1770.

PREFACE.

HAVING, in my former works on Huſbandry, collected into one view, as accurate an account of the ſeveral improvements in Agriculture made by the antients and moderns, as a careful peruſal of their writings, and a due attention to the preſent practice, could enable me; and having ſince given, occaſionally, ſome details of what farther ſteps were taken in our neighbouring nations; I thought it a duty incumbent on me, in return for the very favourable reception with which the public have honoured

honoured my labours, to perſevere, and lay before my countrymen a tranſlation of the following ſheets, lately publiſhed by a Swediſh Nobleman, whom the great WALLERIUS, after congratulating Sweden on the happineſs of having a man of the Count's rank ſo well qualified to treat this ſubject, addreſſes to the following effect, in a letter ſubjoined to his work.

" Go on, moſt noble Count! By ſuch " means the nobility gain every mark " of the eſteem and reſpect of their " country, in a much more pleaſing " manner, than when paid to the dig- " nity procured by anceſtors. From the

" time

" time that the GYLLENBORG family
" firſt diſtinguiſhed themſelves in our
" northern climate, none have ſhone
" more than they, or deſerved better in
" every branch of literature. You, moſt
" laudably, follow the footſteps of your
" illuſtrious progenitors, who have left
" you theſe incitements; and exert the
" utmoſt diligence to become conſpicu-
" ous, not by parchments and portraits,
" but for virtue, wiſdom, and true glory.
" Purſue the path you have entered on,
" and continue the ſame love to your
" country: that country will embrace
" you with equal ardour, and juſtly ſtile
" you HER FATHER. This, SIR, next
" to the heavenly benediction, is the
" greateſt

" greateſt bleſſing that I can wiſh you " on this ſide of immortality. If I " knew a greater, my prayer ſhould " be, that you might enjoy it."

Whoever caſts an eye on the contents of this work, will ſee that our noble author has conſidered his ſubject in every different light in which a thorough knowledge of chemiſtry could enable him to view it: and though reaſoning without experiments is ſeldom of much uſe in practical arts; yet reaſoning founded on real ſcience, and derived from former experiments, may often enable an ingenious huſbandman to draw uſeful concluſions, even from unſucceſ-

ful

ful experiments. In this reſpect, I doubt not but that the following work may be of great utility. Foreign nations have expreſſed their approbation of it, by tranſlating it into their languages; and I hope it will not be leſs reliſhed here, where every improvement in agriculture meets with the kindeſt reception.

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CHAP.

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Page 151, Line 1, *for* extended *read* distended.

THE
Natural and Chemical Elements
OF
AGRICULTURE.

CHAPTER I.

OF THE CONSTITUENT PARTS OF VEGETABLES.

SECTION I.

IN order to know what may be more or leſs beneficial to vegetables, and conducive to their growth, it is neceſſary that we begin with inquiring into their *conſtituent parts*. The knowledge of theſe is acquired *two ways*; namely, *without fire*, by ſeparating them as it were mechanically; and *with fire*, by an accurate chemical analyſis.

Sect. II.

All vegetables, of whatever kind they are, being chemically examined *without fire*, yield,

1. *Oils*, which are uſually expreſſed, and chiefly from the *ſeeds*, though not from all.

2. *Salts*, which are called *eſſential*, and which are different according to the different natures of the plants.

3. *Mucilaginous juices*, of a glutinous conſiſtence.

4. *Gummous juices*, alſo glutinous.

5. *Saponaceous juices*.

6. *Reſins*, and *reſinous and butyraceous juices*.

7. Somewhat reſembling *air*.

8. A *fragrant ſpirituous* ſubſtance.

We muſt not however think, that all theſe are together, and at the ſame time in every vegetable; but only that there is no vegetable from which three, four, or more of the above named principles may not be obtained or ſeparated.

Sect. III.

When vegetables are examined *chemically with fire*, they yield,

1. *Water*, which, if it has little taſte or ſmell, is called *phlegm*.

2. *Salts*,

2. *Salts*, as well *acid* as *alkaline*, which are generally of a *fixed* nature, ſeldom *volatile*. Likewiſe *oily ſalts* are obtained from ſome vegetables.

3. *Oils*, more or leſs fragrant, and which are called *eſſential* when they are united with the *ſpirituous* ſubſtance (Sect. 2. N° 8); or if they have a *fetid ſmell*, they are termed *empyreumatic*.

4. *Earth*, which is either eaſily *vitriable*, or *abſorbent*, or *calcarious*.

Sect. IV.

The *watery parts*, as well thoſe wich are ſeparated *without fire* (Sect. 2. N° 3, 4, 5, 6.) as thoſe which are ſeparated *with fire* (Sect. 3. N° 1.) are found, when purified, to be of the ſame nature with common water. It is proper to obſerve concerning theſe watery parts,

1. That they have always more or leſs *taſte*; and that as all taſte proceeds from ſalt, they neceſſarily contain ſome *ſaline particles*.

2. We alſo find them to be ſometimes *odoriferous*; and as ſmell ariſes from oily and ſpirituous principles, we conclude that they carry with them *oily* and *ſpirituous* particles.

3. As the waters in plants are found to be *moveable in veſſels*, and alſo imbued with *ſaline* and *oily* particles (N° 1. and 2.); we therefore conclude,

clude, that they have a power of *diſſolving*, of *diluting*, and of *mixing* things together.

4. From the moment that all the watery and oily particles of a plant have been expelled by fire, the coheſion of all the other parts which conſtitute the vegetable is deſtroyed: from whence it appears, that *the watery and oily particles perform the office of a glue or cement.*

5. All plants *have not an equal quantity of water in them:* thoſe which have the largeſt ſhare of it are called *ſucculent*, and thoſe which have the leaſt ſhare are called *dry*.

SECT. V.

Earthy particles may be ſeparated from vegetables in two ways, namely, by *putrefaction*, or by being *burnt to aſhes* and duly *waſhed*. We find that by theſe means we can obtain from plants earths of *three* kinds;

1. A *vitriable* earth, ſuch as is obtained from all *farinaceous* and *nouriſhing* plants. This earth is the more eaſily vitrified, the more nouriſhing the plant was from which it was taken. It is in part diſſolved by mineral acids.

2. An *abſorbent* earth, ſuch as is ſeparated from *ſmall*, *aromatic*, *medicinal*, and other plants

It attracts and abſorbs ſome moiſture, and is more eaſily diſſolved in mineral acids than the former; but on the other hand it is more difficult to liquefy.

3. A *calcarious* earth, which is obtained only from *hard vegetables* and *trees*. It agrees in many things with the mineral calcarious earth, and yet differs from it in ſome reſpects. It becomes liquid in a very ſtrong fire, and turns into a *green glaſs*.

It is to be obſerved concerning theſe earths;

A. That we frequently obtain *two* kinds of of them from one and the ſame plant: for example, from the hard woody ſhell of *nuts* and *almonds* a calcarious earth is obtained; but from the *farinaceous ſubſtance* of the ſame nuts, we can get only a *vitriable* earth.

B. Mineralogiſts know, that not any *earthy* particles of this kind are to be found any where on the ſurface of the earth, except in the *black mould*, or *turf*; and that they are therefore to be conſidered as diſtinct from every *natural mineral earth*.

C. Leſs of theſe earthy particles is found in the *aſhes* of plants, than was in reality in the plants themſelves before they were burnt; becauſe many of them fly off in burning, and are entangled in the *ſoot*, or, being cloſely united with the oily or watery particles, form the *ſalts*, *oils*, and *juices*.

D. Theſe earthy particles form the *baſis* of, and give *ſolidity* to vegetables. The curious reader may ſee a farther account of theſe earths in the Acts of the Royal Academy of Stockholm, for the year 1760, *page* 142, *&c.*

SECT. VI.

Whether the *ſalts* that are obtained from vegetables *by fire* (Sect. 3. N° 2.) *exiſted in the plants before*, or whether they are not rather *generated and produced by the fire, during the deſtruction of the vegetable*, is a queſtion which I ſhall not determine here.

The *oily ſalts*, which are obtained from ſome plants which grow in hotter climates, either by diſtillation, or by a ſpontaneous precipitation from ſome oils, or laſtly by ſublimation and decoction from reſinous plants, *partly* pre-exiſted in ſome parts of the vegetables, and ſeem *partly* to be produced by a new combination of the parts.

If we conſider the *eſſential ſalts* obtained *without fire*, we obſerve,

1. That *in ſome vegetables there is a manifeſt acid*, known by its *ſour* or *auſtere taſte*, which ſhews that the acid is combined with an earthy principle; or it ſometimes taſtes *ſweet*, which proceeds from the *acid*'s being joined to an oily principle.

2. That

2. That *in others there is a more hidden acid*, which is diſcovered by ſuffering the juice of the plant to be purified by reſt, then pouring off the clear, and examining it on *filings of ſteel*; by which mixture it becomes of a *darker colour*, and *taſtes of iron*; or it may be tried on other *metals*, by which the colour will be changed; or the juice may be tried with a pure *fixed alkaline* ſalt, which will excite ſome motion in it; or the ſame effect may be produced by *chalk*.

Remark. Theſe appearances are obſerved in the juices of *cabbage*, *beet*, *fumitory*, *lettuce*, *parſley*, *radiſhes*, *wild navews*, &c.

3. That *the acid of vegetables is different from all mineral acids*; for the vegetable acid is milder and more friendly to the human body, not being corroſive; and it exhibits other phænomena than the mineral does.

4. That the *eſſential ſalt* of a plant is the acid of that plant combined with *oily* and *earthy* particles, brought to a ſolid conſiſtence, and cryſtallized. Theſe ſalts generally require twenty times their weight of water to diſſolve them; and when they are laid on live-coals, the oily parts go off in ſmoke, and leave a *coal* behind.

5. That the *eſſential ſalts* are compoſed, as before ſaid, of parts which become volatile in the

fire (N° 4.); and therefore they cannot be obtained by fire.

6. That the ſalt ſo named, being compoſed of an acid, of oil, and of earth (N° 4.) often approaches to the nature of *neutral ſalts*, and yet is not perfectly of that kind, as DE LA GARAYE aſſerts it to be in his *Chem. Hydraul.* though he acknowledges at the ſame time that it is very different from the common chemical neutral ſalt.

7. That *eſſential ſalts are different, as to their qualities and natures, in different plants.* Some chemiſts are of opinion that theſe eſſential ſalts may be divided into different claſſes, and enumerate *five*, namely, the *acid* or *tartareous*, the *ſweet*, the *bitter*, the *ſalt* or *muriatic*, and the *vitriolic*. But as DE LA GARAYE rightly obſerves, *a different eſſential ſalt may be obtained from almoſt every plant.* The different *taſte*, *colour*, and *ſmell* of different plants, take undoubtedly their origin from *different ſalts*, or from *the different combination of their ſalts.* It is not yet fully decided, whether this difference in the eſſential ſalts ariſes from a *different acid*, which ſeems very probable; or from *the different combination of the acid with the oily and earthy particles, in different proportions.* Perhaps both cauſes take place.

8. That

8. That *no eſſential ſalts, or others reſembling them, are found in the mineral kingdom*; but that they are manifeſtly different from every mineral ſalt, as is demonſtrated by mineralogiſts.

9. That *eſſential ſalts, in the form of cryſtals, cannot be obtained from every plant:* for, *1ſt. Plants which have mucilaginous or viſcous juices*, yield no eſſential ſalts by cryſtallization, becauſe the ſaline particles are enveloped in the mucilaginous ſubſtance, unleſs it be attenuated by fermentation; and by that operation, a new combination of parts takes place. *2dly. Plants which abound in oily particles* likewiſe yield no eſſential ſalt in cryſtals; for the oils intangle the ſalt. And hence, *3dly. Aromatic plants* yield very little eſſential ſalts, becauſe of the oil they abound in; nor are thoſe ſalts eaſily obtained from *dry* plants, for want of water to diſſolve them. But DE LA GARAYE teaches, in his *Chem. Hydraul.* that, by *rubbing them in water*, eſſential ſalts may be obtained from all plants.

SECT. VII.

The *oils* of vegetables are, either

A. Eſſential (Sect. 3. N° 3.) obtained by a *ſlow fire*, and ſometimes by *expreſſion*, from the rind of certain fruits. Theſe oils, in different

plants, are different in *colour*, *taſte*, *ſmell*, *conſiſtence*, and *gravity*; and they are alſo different in their nature and qualities, ſome in time becoming either *reſinous*, or *a ſaline body*, or *camphire*.

B. Unctuous (Sect. 2. N° 1.) which, on account of the greater quantity of *earth* and *thick oils*, are viſcous, and have almoſt a ſolid form. They are obtained from moſt ſeeds *by expreſſion*, without fire, and ſometimes by *boiling*, in which laſt caſe they are called *boiled oils* *. The oils of this claſs are alſo different in different plants, as well in *taſte* as in *ſmell* and *conſiſtence*: by *boiling* they become *acrid*, *rancid*, and contract a leſs agreeable *ſmell*. which they alſo do by *long keeping*, when they depoſit their *mucoſity*.

C. Or *empyreumatic*, which can be ſeparated only by means of fire, and are found to be nearly of the ſame nature in all vegetables. By long keeping they become of a *pitchy* nature, and conſiſt of a great proportion of *earth* and *coarſe ſalt*.

It is to be obſerved of theſe oils,

1. That they conſiſt or are compoſed of *an inflammable* and *earthy matter*, by means of an *acid* combined with water, as is known to chemiſts.

* We have no ſuch.

2. That

2. That the differences of theſe oils is to be ſought for, as well in the different nature of the acid (Sect. 6. N° 1, 2, 3.) as in the different proportion of the parts conſtituting the oils (N° 1.) And,

3. That the *vegetable oils* are diſtinct from the mineral oils, as the chemiſts ſhew at large.

Sect. VIII.

The *mucilage* (Sect. 2. N° 3.) which is found in ſome plants, and which is ſoluble in *water*, but not in *ſpirit of wine*, is, in it's mixture, compoſed of *water*, an *acid*, *earth*, and a ſmall quantity of *oil*.

This *mucilage* is however ſometimes *thin*, when the quantity of *acid* and *water* is greater, and ſometimes *thick*, when the *oil* and *earth* predominate.

Let us alſo obſerve, that *no ſuch mucilage is met with in the mineral kingdom*.

Sect. IX.

The *gummous* particles in vegetables (Sect. 2. N° 4.) likewiſe ſoluble in *water*, and not in *ſpirit of wine*, are nearly akin to the *mucilaginous* as to principle; with this only difference, that there is leſs *water* in the *gums*, whereby they have a more

ſolid conſiſtence. *They are never met with in minerals.*

SECT. X.

The *ſaponaceous* particles (Sect. 2. N° 5.) are obtained from ſome plants, and may be uſed inſtead of artificial ſoap. They are compoſed of *water*, *earth*, *oil*, and *ſalt*, mixed in ſuch proportions as to be ſoluble in water, or in ſpirit of wine.

Theſe ſaponaceous principles are often met with in vegetables, but not in minerals. Many chemiſts give a full account of the ingredients uſed for making *artificial ſoap*.

SECT. XI.

Reſinous particles (Sect. 2. N° 6.) ſoluble in ſpirit of wine, and not in water, are, either in a more *liquid* form called *balſams*, or in a *harder* called *reſins*; or *extenſible*, called *elaſtic reſins*; or of a more *tenacious coheſion*, called *wax*; or more *crumbly*, called *camphire*; or *fatter*, called *butter*. Theſe are diſtinct from one another, and yet agree in ſome more general properties.

We obſerve of theſe reſinous bodies,

1. That

1. That they conſiſt of an *oil* and a *coagulating acid*; though it muſt be acknowledged, that a reſinous body may be formed of *oil alone*, the watery particles being diſſipated, as BOERHAAVE obſerves in his *Elem. Chem. Tom.* II. (Sect. 7. N° 1).

2. That *the oil and the acid* in reſins cannot be ſeparated by *diſtillation*, becauſe not only the one links the other, but they are ſo far changed into one another, that, in ſeparating them, they are deſtroyed.

3. The reſins differ *according to the varieties of the oils*; and ſome difference may alſo ariſe from the *difference of the acids*.

4. Such reſinous juices are not found in minerals. *Amber* and *ambergris* ſeem indeed to approach to the nature of theſe reſins; but the difference appears by comparing their natures and experiments made on them, as many chemiſts have ſhewn.

SECT. XII.

The principle of air, which is found in vegetables, is either an *elaſtic fluid*, which may however be ſeparated without entirely diſuniting the parts of the plant; or *unelaſtic*, as has been demonſtrated by Dr. HALES's experiments in his *Vegetable Statics*,

Statics, by thoſe of M. ELLER, related in the *Berlin Memoirs*, and by thoſe of others; in which laſt caſe it cannot be ſeparated without a total deſtruction of the vegetable: for there is no way to ſeparate this air from bodies, but by a *ſtrong heat*, or, which here amounts to the ſame, by *fermentation*. We leave to others the taſk of explaining whether this air does actually exiſt in bodies, and whether from an elaſtic fluid it becomes a ſolid body; or whether it may not rather be conſidered as a *new production*. We ſhall hereafter examine wherein air contributes to vegetation.

SECT. XIII.

The *ſpirituous* ſubſtance, which differs in almoſt every kind of plant, has ſcarcely any weight: one may however ſeparate it with *water* and with *ſpirit of wine*, as appears by *odoriferous diſtilled waters*, and *odoriferous ſpirits*.

This ſpirituous principle ſeems to be of *two kinds*: either it has a *fragrant ſmell*, like to that of the *ethereal oils of balſams*, and of *reſins*; or it has a *ſtrong*, *penetrating*, and *leſs agreeable ſmell*.

We obſerve on this ſubject,

1. That the ſpirits found in plants, as well as the ſmells which are peculiar to *vegetables*, may be increaſed

increaſed or diminiſhed, by culture, by the nature of the ſoil, and by other circumſtances, as d'ALIBARD has remarked in his *Mém. de Mathem. et Phyſ. Tom.* I. From whence it evidently appears, that vegetables can preſerve the mixture of their other parts, without theſe ſpirits; juſt as we ſee that a tree, of any kind, may loſe it's ſmell, without the leaſt apparent change in the different parts of which it is compoſed.

2. This *ſpirituous* ſubſtance, which differs according to the diverſity of plants, ſeems to draw its origin from the *difference of the acids* (Sect. 6.) *and other ſalts, mixed with the different oils.* Thus, to confirm our opinion by ſome examples, the *acid of ſalt* mixed with an inflammable acid, yields a ſmell of *garlic*; all the *mineral acids*, thoroughly mixed with *ſpirit of wine*, exhale a pleaſing *aromatic* ſmell; *metals* aſſociated with acids emit, ſome an agreeable ſmell, others a diſagreeable one; not to ſay farther, that acids joined to aromatics heighten their ſmell; that alkaline ſalts diminiſh it; and that oils extracted by an alkaline ſalt loſe their ſharpneſs. Beſides this, it is alſo well known, that plants and their oils loſe their taſtes as ſoon as theſe ſpirits are gone off, and that all their taſte proceeds *from their ſalt.* We do not deny that eſ-

ſential

ſential oils loſe their ſmell by means of ſtrong acids; but this change is occaſioned, on one hand, becauſe they aſſume the nature of reſin, and on the other, by the violent action of the acid, which deſtroys the adheſion of the particles of the oils.

3. Though *theſe ſpirits* of the plants are much finer and more ſubtile than thoſe which are raiſed by *artificial fermentations*, it ſeems however highly probable, that they are produced through the cauſes we have noticed, by means of the *natural fermentation*, which begins and exiſts in all ſeeds, from the moment of their germinating, and which conſtitutes their nature (N° 2). This is proved, not only from the *ſmell* which they emit whilſt germinating, but alſo by the conformity of our aſſertion with d'ALIBARD's experiments; from which it is evident, that ſeeds which uſually produce odoriferous plants, being ſown in *ſandy ground*, and having germinated there, have produced plants *deſtitute of ſmell*, and which have remained ſo, though afterwards tranſplanted into a richer ſoil, in which otherwiſe thoſe very plants are accuſtomed to retain an agreeable ſmell. For as the artificial fermentation may be advanced, or retarded, by divers exterior cauſes, we think that likewiſe the *natural*, which commences in the ſeeds of vegetables

tables from the time of their germination, may be increaſed or diminiſhed by various exterior cauſes and circumſtances (N° 1.) and that there may reſult from thence a ſtronger or weaker ſpirituous principle. From thence alſo comes, that J. D. MAYOR has called it *the fermenting ſpirit*, and BOERHAAVE, the *rectifying ſpirit*.—We ſhall hereafter explain *this kind of fermentation*.

Remark. JUNGKEN, in his *Experiments on the principles of natural things*, and ſeveral others, have endeavoured to deduce this *ſpirituous* ſubſtance from what is called *the ſpirit of the world*, becauſe they thought it aſſumed a different ſpecification according to the circumſtances; mineral in minerals, vegetable in vegetables, and animal in animals. GODFR. AND. HOFFMAN, not long ago revived, in his Treatiſe *de Oeconom. Phyſ.* P. 2. the opinion, or rather the fable, of ſome antients, purporting, that there is in plants a certain *material ſpirit*, which however is not in itſelf corporeal, and that it is on this ſpirit that the whole of the vegetation and ſtructure of the vegetable body depends. But it is enough to have indicated theſe ſuppoſitions.

SECT. XIV.

Sect. XIV.

Having ſufficiently ſhewn in the foregoing articles, what is beſides particularly demonſtrated in the chemiſtry of natural bodies, namely, that the *reſinous juices* are compoſed of *oil* and *acid* (Sect. 11. N° 1.); and on the contrary the *ſaponaceous*, the *gummous*, and the *mucilaginous*, of particles of *water*, *earth*, *oil*, and *ſalt*, combined in a different proportion (Sect. 8, 9, 10.); it naturally follows, that theſe juices cannot be conſidered as the principles of vegetables, but that they draw their material origin from *water*, *earth*, *ſalt*, and *oil*, which are of different natures, and mixed in different proportions, and which take the nature of theſe juices in the plants themſelves; ſince no ſuch are found in the mineral kingdom, as was before ſhewn.

Sect. XV.

It is demonſtrated in the chemiſtry of natural bodies, that all *oils* are compoſed of an *inflammable matter*, mixed, by means of *acids*, with *earthy* and *watery* parts; as alſo, that all *ſalts* are compoſed of *watery* particles, joined to *inflammable* ones. And it has likewiſe been demonſtrated, that the

the *oils* and *ſalts* which are contained in the vegetable kingdom, are not found in the mineral kingdom (Sect. 6, 7.): It appears from hence, that the *oils of vegetables*, and their *ſalts*, are compoſed of the principles which we have mentioned, that they are found in the plants themſelves, and that they are formed in them.

Sect. XVI.

It is evident from what has been ſaid, that *water*, *earth*, *ſalt*, and *oil* (Sect. 14, 15.) ought to be conſidered as the conſtituent, material, and *immediate* parts of vegetables; and, on the contrary, *water*, *earth*, and *inflammable matter*, (Sect. 15.) as their *more diſtant* material principles.

CHAP.

CHAP. II.

OF THE PRINCIPLES OF VEGETATION IN GENERAL.

SECT. I.

VEGETATION is a ſucceſſive change and increaſe of a plant, which is brought about by a motion of the juices, whereby the nutritive particles, by ſome interpoſition, or appoſition, or by both together, promote the extenſion and growth of the plant.

SECT. II.

By *the principles of vegetation* we underſtand, not only thoſe materials, whether compound or mixed, which enter into the compoſition of vegetables, as *conſtituent parts*, and thereby promote vegetation; but alſo thoſe which help vegetation, either *inſtrumentally* or *actively*.

SECT. III.

A vegetable is an organized body, deſtitute of the power of locomotion, and which draws in the ſubſtance of its nouriſhment and growth by pores or veſſels placed on its outer ſurface.

SECT.

SECT. IV.

From this definition of a vegetable body (Sect. 3.) it is eaſy to conceive, that no ſubſtance can enter into the body of a vegetable, but what can be abſorbed by the pores or very ſmall mouths of the inhaling veſſels, which are ſo minute that they cannot be ſeen by the naked eye, and are not very different from the exhaling veſſels through which water tranſpires inceſſantly, in the form of vapour. They are likewiſe of the ſame nature as the abſorbing veſſels in the ſkin of animals, as appears from Dr. HALES's *Statical Experiments*, and more particularly from thoſe of GUETTARD, in the *Hiſtory of the Royal Academy of Sciences, for the year* 1748. We alſo know that roots, eſpecially the bulbous, hung up againſt a wall in a moiſt place, will grow, ſolely from the vapours in the air; and hence we conclude, that *vegetables cannot receive any other nouriſhment than what can be abſorbed in an extremely ſubtile fluid vapour.*

SECT. V.

The growth of vegetables requires,

1. *A matter capable of nouriſhing them*; for it is not to be conceived that plants can vegetate and increaſe

increaſe without a nutritive matter to feed them. This is the object in view with thoſe who think that almoſt the whole of agriculture conſiſts in *fattening* the land with dung.

Remark. We do not deny that the *viſcous* or *mucilaginous* juices, nay, even the *farinaceous ſubſtance* adhering to the bulbous roots and ſeeds of plants, being rendered more eaſily moveable by the acceſſion of water, may become a nouriſhment of plants; for it appears from BONNET's experiments, in his *Inquiries concerning the uſe of the Leaves*, that the germs of kidney-beans deprived of their coverings, put into earth, and frequently watered, grow, and even bloſſom, notwithſtanding their weak and tender ſtructure. From hence it is evident, that, in the beginning of vegetation, plants may receive ſome nouriſhment from theſe juices and farinaceous ſubſtance; but this will by no means be ſufficient for the whole of their nouriſhment: for who can imagine, that from the ſmalleſt ſeed, a large plant or tree, with branches, leaves, and fruit, can grow to its due ſize without an acceſſion of other food.

2. It is neceſſary that this nutritive ſubſtance be ſo *mixed, diſſolved, and attenuated*, that it can enter into the ſmalleſt pores or veſſels ſpread on the ſurface of plants; and that it be applied immediately to the ſeeds or plants, which are deſtitute of the power of locomotion. They who plead that *frequent plowings* render the land fruitful, have this requiſite chiefly in view.

3. It is neceſſary that the ſeeds or plants be indued with *a natural diſpoſition*, not only to receive the food thus brought to them, but alſo to carry it farther, and diſperſe it in the circulation of their juices. This is the object aimed at by thoſe who ſtudy to increaſe the fertility of the ſeed by *ſteeps*, or other means.

4. It is alſo neceſſary, that, as much as poſſible, every thing be removed which can retard or deſtroy the nutrition and growth of plants. This is the intention of thoſe whoſe firſt ſtudy it is to remove every *external hindrance* of this kind.

Sect. VI.

Plants cannot be nouriſhed by heterogeneous ſubſtances. They can receive no growth from any *mineral earth*, from *ſulphur*, *bitumen*, *ſtony*, or *metallic ſubſtances*, theſe not being homogeneous

to

to the nature of plants, nor capable of being aſſimilated to vegetable, any more than to animal bodies. Hence we conclude, that if any ſubſtance is offered as food, of a different nature from the body to be nouriſhed, that difference muſt be taken away, to render it homogeneous; and hence it appears, that *whatever can afford nouriſhment to plants* (Sect. 5. N° 1.) muſt be either,

1. *Subſtances analogous to, or of the ſame nature with what pre-exiſted in the plants* (we have ſhewn in Chap. I. wherein they conſiſt); or,

2. *Such as can be changed into a ſtate ſuited to the nature of the plants with which they are to be combined.* That *water* and *inflammable matter* can undergo this change, we have already ſhewn (Chap. I. Sect. 15.) and ſhall hereafter demonſtrate ſtill more fully.

Sect. VII.

There being *two kinds of ſubſtances* from which vegetables derive their *growth* (Sect. 6.) namely, the *analogous* and the *tranſmutable*; it is to be obſerved, that *vegetables flouriſh quicker, and more, with food analogous to their nature, than with that which is to be changed into their nature.* This is confirmed by conſtant *experience*, from which it appears,

appears, that vegetables thrive quicker and better in rich and oily ſubſtances, than in ſimple water or inflammable matter; for plants which grow in matter analogous to them, *grow almoſt continually*; whilſt thoſe which grow in matter which muſt be changed into their nature, neceſſarily require *a conſiderable time and power for the tranſmutation of the nutritive ſubſtance.*

Sect. VIII.

The food of plants cannot enter the pores and mouths of their veſſels, till it has been thoroughly *diſſolved* and *ſubtilized* (Sect. 4.). There muſt therefore be the means of effecting this *ſolution* and this *attenuation*. *Water* enjoys this property of diſſolving, diluting, and attenuating (Chap. I. Sect. 4.); as do likewiſe *ſalts*, by which *oils* are not only compounded (Chap. I. Sect. 15.) but may be made to mix with water. We ſhall call theſe means *inſtrumental.*

Sect. IX.

The *ſubſtances* which give increaſe to vegetables, are either,

1. *Nutritive*, on which the extenſion and growth of the plants depend (Sect. 6, 7.); or,

2. *Inſtrumental*, by which the attenuation and mixture of the component particles are effected (Sect. 8.).

Sect. X.

Theſe ſubſtances, meaning both the nutritive and the inſtrumental (Sect. 9.) being of themſelves immoveable and merely paſſive, *require an agent*, which ſhall not only make them act mutually and reciprocally on each other, and diſſolve and mix them; but which ſhall alſo forward them to the ſurface of the vegetable (Sect. 5. N° 2.). This active principle of vegetation, by which the motion of the nutritive and inſtrumental parts is excited, we call the *external agent*, which can be no other than the *air*, and chiefly *heat*, upon which all motion and all fluidity, even of the air itſelf, depends.

Sect. XI.

We before obſerved, that the growth of vegetables requires *a diſpoſition and aptitude in them to be nouriſhed* (Sect. 5. N° 3.); for though they are organical bodies, yet they have not a machine whoſe functions anſwer to thoſe of the heart in animals,

animals, and by means of which the juices can be diſtributed through every part of the body. It is therefore neceſſary that vegetables ſhould have another *active and formal* principle, not only to draw in their food, but alſo to diſtribute and even to multiply it. This principle is two-fold:

1. *Intrinſecal*, conſiſting in the nature of the acid itſelf, and in the *power*, as well *nutritive* as *multiplicative*, given by God to all vegetables. From this proceeds the whole of the vaſt *variety* in plants, with regard to their ſtructure, time of growing, diverſity of fruits, &c.

2. *Extrinſecal*, which however cannot produce any thing if the *intrinſecal* principle (N° 1.) does not co-operate with it, as alſo this laſt remains inactive if it is not aſſiſted by the extrinſecal. This extrinſecal principle depends on a cauſe operating externally, and is the ſame as that we before called the *external agent* (Sect. 10.)

Sect. XII.

It plainly appears from what has now been ſaid, that we are to diſtinguiſh two *active* principles of vegetation, namely, an *extrinſecal* (Sect. 10, 11.

N° 2.) and an *intrinſecal* (Sect. 11. N° 1.) without which vegetables cannot grow.

Sect. XIII.

There are many obſtacles (Sect. 5. N° 4.) by which theſe *active* (Sect. 12.) or *paſſive* (Sect. 9.) principles may be weakened, perverted, or deſtroyed. Experience however teaches us, that they conſiſt chiefly, either in *too much moiſture*, or *too great drought*, or in a certain *aceſcent* quality, or by ſome other *alteration in their nature*, or for want of a ſufficient acceſs of the *active principles*. As to the reſt, theſe obſtacles vary according to the diverſity of the active and of the paſſive principles, from the nature of which laſt, and their manner of operating, a better knowledge of the former may be obtained, as will be more particularly noticed hereafter.

CHAP. III.

OF THE INTRINSIC POWER OF SEEDS WHEREBY THEY MULTIPLY THEIR KIND.

SECT. I.

PLANTS are indued with a *two-fold power*, namely,

1. A *nutritive power*, which regards the preſervation of their own body.

2. A *multiplicative power*, which tends to the production of a new body.

It would ſeem as if this laſt power depended on the firſt: but experience teaches, that theſe powers do not always exiſt in the ſame degree; for where the nutritive power is the ſtrongeſt, the multiplicative power frequently languiſhes; and where the multiplicative power ceaſes, the nutritive power does not always ceaſe. Without entering into particulars, there are vegetables which become prolific only every other year, or at a greater diſtance of time; and ſome which act more powerfully in

nutrition and growth, than in fructification. Theſe powers ſhould therefore be conſidered ſeparately; to which end we ſhall begin with the multiplicative.

Sect. II.

Obſervations teach us, that vegetables are propagated, or multiplied, not only by the *ſeed*, but alſo by the *bud*, *leaf*, *branch*, *root*, and *joint*: whence we may conclude, that their multiplicative power is placed not only in the ſeed, but likewiſe in the body of plants. Chr. Wolfius, in his Treatiſe *de mirif. Sem. multiplic.* has ſhewn by experiments, that *there is a multiplicative power in the knots between the lower joints of plants, and that theſe places may be conſidered as ſeminal capſulæ, from which new roots and buds may be protruded.* But as this multiplicative power, which exiſts in the bodies and parts of vegetables, takes its firſt riſe from the multiplicative power of the ſeed, ſeeing that there is no plant which cannot be propagated by its ſeed, we ſhall firſt treat of *this power in the ſeed.*

Sect. III.

If we conſider the *ſtructure* of the ſeeds of plants, we ſhall find that they conſiſt,

1. Of

1. Of *membranes.*
2. Of *Lobes.* And,
3. Of *a germ with its root.*

Of theſe, the *membranes* cannot be conſidered as eſſential parts, but only as coverings, which contribute nothing to the future plant, and are uſually found empty, adhering to the roots of plants. The *lobes*, which are of a *farinaceous ſubſtance*, ſerve as nouriſhment to the germ or embrio of the plant, eſpecially when it firſt begins to vegetate; as appears from their being gradually conſumed, and from BONNET's experiments, (Chap. II. Sect. 5. N° 1. *Rem.*): Hence it alſo appears, that the future plant is to be looked for in the *germ.*

SECT. IV.

The ſeeds of plants, eſpecially thoſe of the corn kind, being chemically examined, in order to diſcover their conſtituent parts, ſhew,

1*ſt.* That *no ſalt whatever* can be obtained from perfectly ripe ſeeds *boiled in pure water*, though unripe ones communicate to it a certain *acidity*; but that, on the contrary, they yield a conſiderable quantity of a *mucilaginous* or *gummy* ſubſtance, and

that the more, the riper the seed is, and the purer the meal.

2*dly*. By *distillation* they yield, first *an oily spirit somewhat acid*, then an *oil*, leaving the *earth* behind.

3*dly*. *Burnt in an open fire*, a smoke arises, and they grow black; the fire being increased, they flame, and are turned into a coal; and after all the oily and volatile particles are consumed or dissipated, they leave a small quantity of a *white vitrifiable earth*, which is obtained in so much the less quantity, and is the easier vitrified, the more nourishing the seed was. Thus *rice* yields less and more easily liquefied earth than *wheat*, *wheat* less than *oats*, and so on. (*See Acta R. Acad. Stockh.* Vol. XXI. P. II. p. 147, &c.) We may hence conclude, that *the farinaceous substance consists of an earth which derives great part of its origin from water, by a motion peculiar to such seeds; the earth being combined with a great proportion of oil, likewise reduced to earth by a similar motion, to which was added a small quantity of acid water*; for it is demonstrated by experiments, in the *Acta R. Acad. Stockh.* Vol. XXI. that water may be turned into a *vitrifiable* earth, and oil into an *inflammable* earth.

SECT.

SECT. V.

It is found by experiment,

1*ſt.* That the multiplicative power of ſeeds remains naturally and of itſelf inactive, unleſs an *external efficient cauſe* is added, namely, *warmth and air* (Chap. II. Sect. 11. N° 2.) in due proportion to ſet that power in motion.

2*dly.* That a due quantity of *moiſture* is alſo neceſſary, to moiſten, reſolve, and render the parts capable of motion; for ſeeds kept in dry places will not vegetate.

3*dly.* To the above muſt be added *a ſufficient quantity of intrinſic food* of a good quality (Sect. 3.) For this reaſon it is that thoſe *ſeeds are judged to be the moſt fruitful, which are largeſt, heavieſt, and fulleſt of farinaceous matter, which crack when preſſed between the fingers, and ſink when put into water; and thoſe leſs fruitful, which are ſmaller, rougher, lighter, and leſs full of farinaceous ſubſtance; which become flat, without cracking, when preſſed between the fingers, and which ſwim in water.*

SECT. VI.

In order to diſcover *wherein this multiplicative power conſiſts*, it is neceſſary that we attend to the appearances which ariſe during the germination. From theſe we know,

1*ſt.* That ſeeds *ſwell* ſucceſſively and gradually when *moiſtened*, a due degree of *heat and air* concurring (Sect. 5.); whence it appears that the moiſture is abſorbed by the pores of the ſeed.

2*dly.* We find that, afterwards, an intrinſic heat ariſes, and becomes more and more ſenſible, ſo as to be felt by the hand, as is the caſe in a heap of corn that ſprouts in the granary; and that the ſeeds then diffuſe a ſingular ſmell, which ſhews that the *taſte* of the juices is changed, and we at the ſame time ſee the firſt lineaments of the root and leaves.

3*dly.* This motion being continued, we find that the membrane is gradually emptied in proportion as the *root and leaves extend*; and that the intrinſic juice again changes it's *flavour*.

It appears evidently from theſe and other circumſtances, different indeed in different vegetables according to their natures, that there exiſts in germinating ſeeds an intrinſic motion, by means of

of which the juices and nouriſhment of plants undergo a total change, different in each according to it's nature; and that therefore a complete fermentation takes place, as is ſhewn in *natural chemiſtry*. From hence we conclude, *that the multiplicative power of ſeeds conſiſts in a certain fermentative motion, and that the difference ariſes from a ferment peculiar to each ſeed, communicated to the plant as it grows.*

Remark I. If we add to what has been ſaid of *fermentation*, as well in the ſeeds as in the bodies of plants whilſt germinating and growing, that all the *principles* of fermentation, as well *material* or *paſſive*, as *active*, reſide in vegetable ſeeds and juices (Sect. 4, 5.); that all expreſſed juices ferment of themſelves; that the juices can be neither attenuated, nor mixed, without an intrinſic inteſtine motion; and that a *ſpirit* can be obtained from this kind of fermentation, as ſucceſsfully as from an artificial fermentation (Chap. I. Sect. 13.); we think that our theory of fermentation will be eſtabliſhed beyond all doubt.

This theory is not new, for it was long ago adopted by MALPIGHI, *de Cort.* p. 5; DIGBY, *de Veget. Plant.*; DEDY, *Eſſai de Phyſ.* LEMERY, *Mem. de l'Acad. de Paris l'an* 1717; VALLEMONT, *Curioſ. de la Nat.* HOMBERG, *Mem. de l'Acad. de Paris* 1703 *and* 1709; EYSFARTH, *de Morbis Plant.* MARZUCCHIUS, *Elem. Chem.* KIESLING, *de Veget.* KRAFT, &c.

Remark II. That theſe fermentations are different in different plants, we infer from their different taſte and ſmell. On this principle reſts the whole doctrine of *inoculating* and *grafting:* for we are of opinion that the inoculating or grafting uſed by gardeners, in which we find the juices of the trunk or tree to be totally changed in flavour and diſpoſition, cannot be explained otherwiſe than by means of ſome ſuch fermentation pre-exiſting in the germ, leaf, or root; mechaniſm alone not being ſufficient to produce this effect.

Remark III. It is not eaſy to ſay what is *the ferment of vegetables* which is communicated to their ſeeds, and on which depends the

the whole of their variety. However, to ſpeak freely our mind, we are of opinion that it is by means of the *very fine flour* which riſes thoroughly depurated to the ſummit of the plant when it is in bloom, as *yeaſt* riſes upon a fermenting liquor, that the ſeeds are fecundated in their very firſt formation.

Remark IV. It is owing to this fermentative motion, that ſeeds which are gathered in a rainy ſummer, and have in the leaſt degree undergone this operation whilſt in the ear, become afterwards leſs fit to be *leavened for bread*, becauſe their natural ſtate is altered by the previous fermentation; though a ſtronger leaven, and continuing the operation longer, may bring about a due degree of fermentation.

SECT. VII.

As every artificial fermentation, ſo likewiſe this natural one of vegetables, and with it the *multiplicative power and vegetation of ſeeds*, may not only be *changed* according to *the diverſity of the ferment* (Sect. 6. *Rem.* II. III.); but it may alſo be

increaſed

increaſed or *diminiſhed* by internal and external cauſes and circumſtances.

SECT. VIII.

The multiplicative power of ſeeds may be promoted and increaſed,

1. *By ripeneſs*; for by this the ſtructure of the ſeed is rendered more perfect, the nutritive juice is more elaborated, and rendered fitter to undergo the neceſſary fermentation. *Ripe ſeeds ſhould therefore be choſen for ſowing*: and thoſe farmers act very wiſely, *who leave their wheat-ſheaves for ſome time in the field expoſed to free air, thereby to ripen them more perfectly; taking care however to cover them from wet.*

2. *By a due degree of heat*; for with this no moiſture, no fermentation can ariſe, and therefore no germination. The requiſite degree of heat will be treated of in the next Chapter. On this account it is, than when corn is laid, its ſeed is leſs prolific, for the heat cannot penetrate it duly on all ſides upon the ground. Trees are generally moſt flouriſhing and fulleſt of branches on their ſouth ſide, becauſe that part is moſt expoſed to the heat. *Seed corn ſhould therefore be choſen from*

large

large fields, open on all ſides to the heat of the ſun whilſt the corn was growing and the ſeed ripening.

3. *By a due degree of moiſture and richneſs of the land.* For as all fermentation requires a due proportion of *watery*, of *ſaline*, and of *oily* particles, as the chemiſts have demonſtrated; ſo the multiplicative power of ſeeds requires a quantity of theſe conſtituent parts proportioned to their different qualities. It therefore is no wonder, that *too much moiſture*, or *too great a richneſs of ſoil*, may ſuffocate plants, or render their ſeeds unripe or leſs prolific: becauſe too much moiſture makes the ſoil ſo looſe, that it cannot give a due degree of ſtability to plants, and prevents a due digeſtion and maturation of the juices; whence their ſtrength is employed more in puſhing the ſtem into length, than in fructification. Hence it is that corn ſown in dung ſeldom or never produces perfectly ripe ſeeds. But it muſt alſo be obſerved, that the requiſite quantity of moiſture and degree of richneſs of ſoil varies greatly according to the nature of each plant; for ſome require more and others leſs; and this can be determined only by experiments, which teach us, that *the more farinaceous*

and

and nutritive the ſeeds are, the more they require of moiſture, or of heat, or of both; whilſt leſs farinaceous ſeeds may grow with leſs of either. On this principle it is that ſeeds for ſowing ſhould be adapted to the ſoil.

4. *By a due ferment* (Sect. 6. *Rem.* II.); and in order that this may be duly communicated to the ſeeds, it is neceſſary that the plants bloom in a mild and pleaſant ſeaſon, as experience teaches.

Remark. Can the multiplicative power of plants be promoted, and to what degree, by a change of place and climate? This queſtion may be partly anſwered by what has been already ſaid, and will be more fully replied to in the following paragraph.

Can it be promoted by art? This queſtion will be particularly diſcuſſed hereafter.

Sect. IX.

The multiplicative power of ſeeds is on the other hand diminiſhed (Sect. 8.)

1. *By want of ripeneſs* (Sect. 8. N° 1.)

2. *By cold*, or a want of the due degree of heat (Sect. 8. N° 2.) Hence *woods* are hurtful to corn-fields,

fields, on account of their ſhade and the colder air which blows from them.

3. By *barreneſs and dryneſs of the ſoil* (Sect. 8, N° 3.): for vegetables which grow in a barren ſoil, muſt of neceſſity employ every moment to bring about the due change of their food; and by this means yield leſs prolific ſeed (Chap. II. Sect. 7.)

4. By *want of the due ferment* (Sect. 8. N° 4.)

5. By *age*; for it appears to be with vegetables as with animals, that the older they grow, the leſs they are prolific. Seeds alſo by keeping loſe their *watery* and *oily* particles. Perhaps too the ferment may be ſome how corrupted. We cannot therefore by any means agree with thoſe who hold, that *the longer ſeeds are kept*, the fitter they are for ſowing. Both reaſon and experience prove the contrary.

6. By *a change of climate*; eſpecially when the change is made from a warmer to a colder. The caſe is nearly ſimilar in regard to animals, ſuch as *horſes*, *cows*, &c. Thus, for example, they who import ſeed-wheat from Podolia into Sweden, may have better crops the firſt year; but the difference ceaſes the next: for the multiplicative

power

power of the ſeed leſſens, in proportion as the *heat, richneſs, and nature of the ſoil* are leſſened, or altered. But this ſubject will be farther treated of in Chap. V. where we ſhall inquire into *the action of air upon vegetables.*

Remark. It has of late been much diſputed, *whether plants can change or degenerate into others, by any means owing to the different qualities of the ſoils or ſeeds.* Some abſolutely deny this tranſmutation, as contrary to all received principles; whilſt others endeavour to prove it by examples. I ſhall not enter into the merits of this argument, but only in ſhort declare, that it is not reaſoning but facts which ſhould decide this queſtion; for the ſecrets of nature are not yet fully known. One experiment of ſuch tranſmutation, made with care, will go far towards deciding this queſtion: for from many experiments which do not ſucceed, all that can be concluded is, that this tranſmutation does not take place at all times and in all places. They therefore who diſſuade men from experiments of this kind, are no friends to the advancement

of

of ſciences, or the diſcovery of truth; nor do they act better who themſelves believe, and would perſuade others, that the different and almoſt inſcrutable methods of generation made uſe of by nature are ſufficiently known; not only different in the different kingdoms of nature, but exceedingly ſo even in the ſame kingdom, as is very apparent in the animal kingdom. We therefore recommend this matter to farther experiment.

CHAP.

CHAP. IV.

OF HEAT, SO FAR AS IT PROMOTES VEGETATION.

SECT. I.

AS animals cannot live *without a certain degree of heat*, ſo neither can vegetables. We ſee every year, that as the heat decreaſes in autumn, vegetables proportionally loſe their verdure, and that the returning warmth enlivens every plant: we obſerve alſo, that in cold ſummers, vegetables grow more ſlowly, and that they come to their maturity ſooner in warm ſummers. There is therefore no doubt but that heat contributes greatly to promote vegetation, and the growth of plants. In what manner this is performed, becomes the ſubject of our preſent inquiry.

SECT. II.

That we may know the more clearly in what manner heat promotes vegetation, we muſt obſerve, that there is a *two-fold* heat, namely, one which

which *ariſes out of the earth*, and another *in the air*. We ſhall here conſider both jointly, and mark the effects which proceed from them, not only in the *vegetables* themſelves, but alſo in the *earth* in which the vegetables grow, and in the *air* ſurrounding the vegetables.

Sect. III.

So far as we can judge from the theory of heat, and from its effects, it exerts its power upon *vegetables* in *two ways*.

1. *Actively*, *(a) by exciting and promoting a motion in the fluids*; for ſo ſoon as heat ceaſes, motion ceaſes, and with it all nutrition and generation. When there is no warmth, water and other juices ſtagnate and putrefy, or, in a freezing cold, turn to ice. The nutritive particles cannot therefore be aſſimilated to the nature of vegetables without warmth (Chap. II. Sect. 10.); (*b*) which excites a motion in *the intrinſical active principles of vegetables* (Chap. II. Sect. 11.)

2. Heat operates alſo *materially* upon vegetables, *by adminiſtering a certain nutritive inflammable matter*. It is demonſtrated in natural chemiſtry, that heat conſiſts in *the motion of particles capable*

of

of raiſing heat; and that no *oily or fat* ſubſtance can be generated but by an inflammable matter combined with water by the means of ſalt (Chap. I. Sect. 7. N° 1.). Hence alſo KULBEL, in his Treatiſe *de Fertilitate, Theſ.* 20, is of opinion, that oils and fat are generated from an unctuous and inflammable earth. Of this we ſhall treat more fully hereafter.

SECT. IV.

Heat, whether terreſtrial or aërial, operates *on the earth itſelf* (Sect. 2.) alſo in a *two-fold* manner.

1. *Actively*, by reſolving into vapour the water and oily matter in the earth, and driving them to the ſurface of the plants (Chap. II. Sect. 10.). This purpoſe is peculiarly well anſwered by the *ſubterraneous heat*, which, in a droughty ſeaſon, reſolves into vapours water lodged any where in the earth, and ſo brings it up to the roots. The *ſubterraneous heat* alſo prevents the juices of vegetables from being coagulated by cold.

2. *Materially*, by uniting the fat of the earth with the *inflammable matter*, whether in the earth itſelf, or floating in the air, and by that means rendering it more nutritive and fruitful, as is obſerved

ſerved by KULBEL, in the place before quoted. It alſo fixes and combines the *ſpirituous matter*, in the vegetable kingdom, with the *oils*. Hence it is that rich earths are always warmer than barren ſoils: for theſe laſt being deſtitute of oils, the inflammable matter does not find in them any thing analagous, with which it can be combined.

SECT. V.

Heat exerts its effects on the air (Sect. 2.)

1. *Actively*, either (*a*) *by rarefying it*, whence a motion is excited in the air itſelf, and in the juices of vegetables; or (*b*) *by rendering the air richer in nutritive matter*, by the greater quantity of vapour raiſed into it (Sect. 4. N° 1.).

2. *Materially*, and that two ways, namely, (*a*) *by combining the vaporous, watery, and inflammable particles floating in the air*, ſo as to form *a ſaline principle*, which ſome call an *aſtral ſalt*; or (*b*), by means of *this ſalt*, combining the watery with the inflammable particles, whence is formed *a moſt ſubtile oil*, which may be juſtly called *æthereal*.

SECT. VI.

For heat to produce theſe its effects (Sect. 3, 4, 5.) it is neceſſary,

1. *That*

1. *That its degree be proportioned to almoſt every kind of plant*; for ſome plants can bear a greater degree of cold than others. This diverſity depends *on the different activity of their multiplicative power* (Chap. III. Sect. 6.).

2. *Such a degree of heat is always requiſite, as ſhall penetrate through the bark, and even to the pith of the plant.*

Sect. VII.

Heat is *prejudicial* to vegetables (*a*) when it is *exceſſive*, becauſe it then draws the nouriſhment of plants out of the earth in the form of vapour; and the heat is raiſed ſo high in the veſſels and fluids of vegetables, that the juices, inſtead of being attenuated, are concreted: as in animals, the fluids become a ſolid ſubſtance by too great a heat. Too great a tranſpiration favours this concretion. (*b*) On the other hand, by a *defect* of heat, the motion of the nutritive juices becomes languid, or ceaſes.

Sect. VIII.

Some philoſophers have given the name of *ſpirit of the world, to that principle from which all living bodies have life, vegetation, preſervation, and ſtrength*;

ſtrength; or, *by which every thing that has life is animated, and preſerved in its due ſtate.* Now as this vivifying and preſerving power can be no other than *heat* (Sect. 3, 4, 5,) it is plain that this *ſpirit of the world is no more than the matter of heat*, or *the matter of light, combined with the inviſible particles of inflammable matter*; for it is demonſtrated in natural chemiſtry, that the matter which contains the principles of heat, is compoſed of the matter of light, and inflammable matter.

Remark. This matter of heat is not improperly called *the ſpirit of the world*, becauſe of its exceſſively *ſubtile nature*, extremely *quick motion*, vaſt *activity*, and amazingly *penetrating* quality; with the ſame juſtice that the extremely ſubtile matter moving in animal bodies, which according to electrical experiments conſiſts of lucid and inflammable particles, is called *animal ſpirit.*

Hence the Stoics, as PLUTARCH informs us, held that *fire was the ſeed of the world*; and ZOROASTER and HERACLITUS ſaid, *that the ſoul of the world was an inviſible fiery ſpirit.* Hence too PARACELSUS was of opinion, that *whatever is generated and grows, proceeds from fire:* (URB. HIERNE *Tent. Chem. Tom.* I. p. 30, *&c.*) and

hence alſo it is called the *vivifying fire*, the *vital ſulphur*, by DENSTONIUS, *Panſoph.* and by CRAMER, *Coll. Chem.* p. 3. Sect. 14.

Some, chiefly of the antient philoſophers, *too refined* in their ſpeculations, thought that *the whole univerſe* was indued with an *animal ſpirit*, as well as man. (LIPSIUS *in Phyſiol. St.* II. *Diſſert.* 10.). They conceived the world to be *a huge animal*, beyond which all was a *void*. KEPLER was nearly of this opinion when he ſaid, that *a ſpecial ſoul was given to this earth*; and ſo was JAMES KOCHEN, in his book *on the pulſation of the artery*.

Others were, on the contrary, *too groſs* in their ideas, when they conceited *the ſpirit of the world* to be *the waters above the heavens*; as ROSENCREUTZER, WAITZIUS, and more; ſo likewiſe were thoſe who thought it to be an *univerſal* or *virgin ſalt*, like CRAUSIUS, in his *Cogit. de Spiritu Mundi*; and laſtly, ſuch as deemed it to be *the vapours raiſed from the earth in the month of October*.

CHAP.

CHAP. V.

OF AIR, SO FAR AS IT PROMOTES VEGETATION.

SECT. I.

NATURALISTS and chemiſts have long ago obſerved, that no ſeed can ſhoot, nor any vegetable grow, in a place *deprived of air*. (BOERHAAVE *Chem.* Tom. I. p. 420. MUSSCHENBROEK *Phyſic.* p. 448, 449.) We have likewiſe ſhewn (Chap. I. Sect. 12.) that there is *air* in vegetables; and upon this foundation it was that Dr. HALES deſired, in his *Vegetable Statics*, that air ſhould be admitted as one of the elements or chemical principles. *It is therefore inconteſtable, that air contributes greatly to vegetation.*

SECT. II.

In order to diſtinguiſh accurately wherein *air* contributes to vegetation, we muſt conſider it in a double reſpect; either *abſtractedly*, as depurated and ſeparated from every heterogeneous ſubſtance,

in which caſe it may be called *ether*; or as *combined* with other particles, in which caſe it has the name of *atmoſphere.*

SECT. III.

Elaſtic air conſidered abſtractedly, or as *ether* (Sect. 2.) promotes vegetation, *actively*, by its power, as well of *rarefying*, which ariſes from heat, as by *condenſing*, which depends on cold; by theſe means exciting an internal motion and fermentation in fluids. (Chap. II. Sect. 10, 11. and Chap. III. Sect. 6.) In this ſenſe *elaſtic air* is as neceſſary to the life of vegetables, as it is to the circulation of the fluids in animals, and to their tranſpiration.

Remark I. *Does air promote the circulation of the fluids by its weight?* BOERHAAVE denies it, thinking that pure air acts only by its *elaſticity*, that it has no weight of its own, and that its weight depends ſolely on the quantity of *vapours* contained in it. He confirms his opinion, by alledging that reſpiration is reſpectively eaſier *on the ſummits of the higheſt mountains*, than in common air rendered equally light by art: for animals are almoſt

ſuffocated

ſuffocated in the air-pump when *a third part* of the weight of *common air* is taken off; yet in the air on the *mountain tops*, which is *lighter by one third*, animals live comfortably. From hence he concludes, that the loſs of weight in the lofty air is ſupplied by its elaſticity, for that otherwiſe the lungs would not be ſufficiently dilated; and therefore, that the weight of the air ariſes from vapours, but that elaſticity reſides in the air. NOLLET has endeavoured to refute this theory: but I ſhall only obſerve here, that *plants which grow on the ſummits of mountains are always ſmaller than thoſe of the ſame kind which grow in plains or vallies.* The *greater elaſticity* of the air on the mountains, or its *greater weight* in the vallies, does not ſeem to be the cauſe of this difference, but rather the *want of heat* and the *ſcarcity of vapour* on the mountains.

Remark II. We cannot determine from experiments hitherto made, *whether air ſaid to be changed into a ſolid un-elaſtic ſubſtance* (Chap. I. Sect. 12.) *contributes materially to vegetation*; ſeeing it is not yet decided

whether that air, which is drawn out of plants, ſhould not be conſidered as a new production, or as an elaſtic vapour, rather than as air brought out.

Sect. IV.

The *air* conſidered as a *compound* ſubſtance called *atmoſphere* (Sect. 2.), is that in which animals breathe, in which vegetables ſpring up, live, and grow, and contains many particles either *exhaled*, or *generated in the air*. We ſhall conſider them in theſe *ſeparate* views, the better to know wherein it is that the air promotes vegetation.

Sect. V.

The particles *exhaled* from the earth which exiſt in the atmoſphere, ariſing either from *the earth itſelf*, or from *bodies exiſting in the earth*, can be no other than ſuch as are *lighter than the air*. The *purer inflammable ſubſtances* are the only thing we know of this kind, which being *reſolved into vapour* by heat, are *volatilized*. The particles of this kind exhaled are,

1. *Watery*, of which an almoſt inconceivable quantity are, by heat, *ſeparated* from the ſea, lakes, rivers, and natural bodies, and rendered *volatile*.

2. *Inflam-*

2. *Inflammable*, which are raiſed into the air by their own quality, from natural bodies, and eſpecially from the earth. Upon theſe the heat of the air depends.

3. *Oily or fat*, which, by means of heat, are reduced into vapours, and volatilized in ſo great quantities, that JUNKER was not wrong in ſaying, in his *Conſp. Ch. Tom.* I. p. 81, that the air, relatively to theſe inflammable particles, and to thoſe we ſpoke of in the foregoing articles, ought to be looked upon as the receptacle, or natural ſeat of the oily and inflammable matter; which ſeems to be ſufficiently confirmed, not only by heat, but alſo by thunder, lightening, and ſeveral other phænomena.

4. *Saline*, as well the *lighteſt moſt diluted acids*, as the *volatile alkalies*, of themſelves liquid and of a ſpirituous quality, and reſolved into vapours; of which however it is obſerved, that but a very ſmall quantity aſcends, ſince only a few indications of ſuch ſaline particles can be obtained from rain-water. They who pretend that the air is full of *nitre*, *ſulphur*, or other *ſolid particles*, *ſaline*, or *ſulphureous*, are groſsly miſtaken, becauſe ſuch bodies cannot become evaporable in ſubſtance.

We are likewiſe perſuaded that no *particles purely earthy*, though reduced to the ſmalleſt dimenſions poſſible, can be raiſed up and ſuſpended in the air. We grant indeed that there are particles of earth very finely levigated floating in this our lower atmoſphere: we alſo allow that *ſmoke*, which contains earthy particles, as a chemical analyſis of it ſhews, carries up with it a ſomewhat earthy: but on the other hand, no one can be ignorant that theſe particles are, either themſelves *inflammable*, or *mixed with inflammable matter*, by which means they float as it were on the waters of the atmoſphere, like an extremely fine duſt. It is likewiſe generally known, that after they have been raiſed to a certain height, either by the air, by heat, or by their being united to inflammable matter, they afterwards fall down inſenſibly of themſelves, as every one may be convinced by expoſing for ſome days to the open air, and in calm weather, linen, glaſs, or any poliſhed body: they will be ſeen to be covered with this duſt as faſt as it falls.

Remark. Several, not acquainted with the operations of nature and with chemiſtry, have attempted to reaſon upon vegetation. Some have imputed it to a certain *ſaline matter*, and to a *nitrous principle which exiſts in the air*,

air, and which they have therefore called *aërial nitre*; others, on the contrary, have thought that vegetables are nouriſhed by *earthy particles which are carried up into the air*, or by particles of the air itſelf: but that both are wrong is plain from what we have already ſaid, and will be farther ſo from what we ſhall hereafter ſay.

Sect. VI.

The particles generated in the air, and which are found in our atmoſphere, derive their origin from the exhaled particles above deſcribed (Sect. 5.), which, being ſeparated and changed by the various motions and frictions they undergo, conſtitute, by a new combination and mixture of parts,

1. *Acids*, which ariſe from the moſt ſubtile, inflammable matter combined with the elaſtic watery vaporous particles, and which are therefore called the *univerſal* or *primitive acid*, approaching to the nature of the *vitriolic acid*, as electrical obſervations, and the acid found in ſome plants, ſeem to indicate.

2. *Oily or ſulphureous particles*, which probably take their riſe in the air from the inflammable matter and water, by means of the *primitive acid*.

Remark. It would ſeem that the *inflammable* particles are not generated anew, but by a kind of circular motion transferred from the earth to the air, and from the air to the earth again.

Sect. VII.

That the particles generated in the air (Sect. 6.) are diſtinct from the exhaled particles (Sect. 5.), we conclude, not only from *the difference of place where they are generated*, and *the different manner in which they are formed*, but alſo more eſpecially from *the different nature of theſe particles*, as is ſufficiently proved by *meteors in the air*, and the marvellous properties of the *aërial ſulphur*.

Sect. VIII.

From what has been ſaid (Sect. 5, 6.) we ſhall infer, *that the air, conſidered as a compound body, promotes vegetation*;

1. *Actively*, and that *in a two-fold manner, (a) by the various changes in it, and by the ſtronger or weaker motion of the winds:* for it is not to be doubted that the changes in the air muſt depend greatly on the nature and quantity of exhalations in it,

or

or on the ſcarcity of watery or inflammable particles, or on cold: and whoever has obſerved that vegetables languiſh in conſtantly moiſt, or conſtantly dry or calm air, muſt know that the changes in the air, and the variety of winds, promote vegetation: for by theſe alternate changes, the circulation of the juices is ſometimes promoted, and ſometimes retarded; the nutritive matter is purified and propelled in the veſſels, and whatever is noxious to the plant is expelled. (*b*) *All the particles in the air, whether exhaled or generated in it, are alſo by theſe changes attenuated, divided, and combined together* (Sect. 8.)

Remark. It is on the principle here laid down, that Baron EDM. GRIPENHIELM, *in his Preface to* MAGNUS STRIDSBERG'S *Treatiſe on the Agriculture of Sweden*, reckons the changes of the air among the principal cauſes of the growth of vegetables.

2. The air contributes alſo to promote vegetation *materially*, by furniſhing thereto the nutritive particles floating in it, whether from *exhalations* (Sect. 5.), or ſuch as are *generated in it* (Sect. 6.). Of this kind are

a. Watery particles, which deſcend and enter into vegetables, in the form of *vapour*, or condenſed into *dew*, *rain*, *ſnow*, *&c.*

b. Inflammable particles, which are agitated and propelled by the motion of the air, and are more eſpecially under the influence of the *ſolar rays.*

c. Subtile, oily, or ſulphureous particles, which are alſo put in action by the ſame cauſe as the former, and ſometimes deſcend with the *watery* particles, from which they can be ſeparated by art (URB. HIERNE *Tent. Chem.* Tom. II. p. 23.); and hence ſuch waters eaſily putrefy, and poſſeſs a ſurprizing power of *fertilizing the earth.* STAHL *(in Zymoth)* is of opinion, that *trees* which grow in gravelly, ſandy, or poor ſoils, ſuch as *firs*, *pines*, *junipers*, &c. draw their nouriſhment from theſe oily and inflammable particles; for from whence can they otherwiſe draw it?

d. Saline particles, which alſo deſcend with the *watery*, and become perhaps the means by which the watery and oily particles may be united. Their exiſtence in the air is proved by many chemical experiments, particularly thoſe of URB. HIERNE in the treatiſe above quoted, and of MARGGRAFF, in Memoirs of the Berlin Academy for the year 1752.

1752. The *ruſting of iron in the common air*, is an inſtance of it offered to every eye.

SECT. IX.

It appears from obſervations, that plants grow but ſlowly within doors, though there be no want of exhalation nor of heat, and though the air have a free motion: for plants require an *open air*. It is alſo known, that the ſeeds of vegetables germinate very ſlowly, if at all, where the *air ſtagnates*, though they have ſufficient moiſture. BOERHAAVE *Chem.* Tom. I. p. 420. MUSSCHENBROEK *Phyſica*. Nor is this peculiar to plants; for *animals* cannot live long in the ſame air; frequent reſpiration rendering it unfit for the ſupport of life: as it is likewiſe obſerved, that *blood* expoſed to the open air takes a bright colour, but a different colour in a cloſe place. Hence philoſophers have concluded, that, beſides the air itſelf, and the various exhalations contained *in our atmoſphere*, there is in it *ſome nouriſhing and recruiting principle, by which the vegetation of plants and the life of animals are ſuſtained.* In imitation of COSMOPOLITA, they have called this principle *the occult food of life*. Now as, beſides exhalations, we do not find any nutritive

nutritive matter in the atmosphere, but the *acid, oily*, and *sulphureous* particles generated in the air (Sect. 6.); we from thence conclude, that *this occult food of life* consists in, or rather depends on, as well the *acid, oily, and sulphureous particles, as the inflammable or electrical, generated in the air, and as it were vivified* (Chap. IV. Sect. 7.) *by the spirit of the world.*

Remark. Others call this occult food of life *night-dew, life distilled from above, rarefied water*; which induced KIRCHER to think that it proceeded solely from the waters he imagined to be above the heavens. On the contrary NOLLET derives this food from *the influences of the heavens*, which seems also to be nearly the opinion of URE. HIERNE (*Paraſc.* Cap. IV. p. 22.) But BOERHAAVE (*Chem.* Tom. I. p. 420.) ſpeaking of this food derived from the air, ſeems to ſuſpect that it ought be imputed ſolely to *ſome elaſtic particles* (Sect. 3. *Rem.*)

SECT. X.

Both this *occult food of life* (Sect. 9.), and the *exhalations in the atmoſphere* (Sect. 5.), promote the

the vegetation and growth of vegetables, in a *two-fold manner*;

1. *Immediately*, by being abſorbed into the vegetable bodies, by their *imbibing veſſels*, and thereby communicated to the circulating fluids (Chap. II. Sect. 4.) Hence it is that trees do not grow when ſtripped of their leaves; and on the contrary the more leaves they have, the more they abound in *fat and reſinous juices*, as is particularly remarked in the *fir* and *pine* (Sect. 8. N° 3.)

2. *Mediately*, by entering into the *earth*, and fertilizing it. That the *earth* does receive theſe particles floating in the air, appears from the common obſervation, that earth which lies buried deep, being turned up and expoſed to the common air, becomes in a few years fruitful. The great power which theſe particles poſſeſs, of rendering the earth fruitful, depends perhaps in a great meaſure on their faculty of *diſſolving and uniting ſubſtances of different qualities*.

SECT. XI.

We muſt not, however, think that the air is at all times, and in all places, equally ſtored with theſe particles; for they vary,

1. *Ac-*

1. *According to the climate,* whether hotter, colder, or temperate. Hence too perhaps it is that poiſons differ in their ſtrength, according to the climate they grow in.

2. *According to the height of the place above the level of the ſea:* for the higher we aſcend in the atmoſphere, the fewer the exhalations are, and the leſs in the heat (Sect. 3.)

3. *According to the diſtance from the ſea, or other large bodies of water, or from foreſts, or waſte land.* The nearer places are to the ſea, the more they enjoy the changes of the air, which is rendered milder and moiſter by the vapours aſcending from the ſea. In foreſts, the warmth of the ſun can ſcarcely reach the earth, and this renders them the more ſubject to extreme colds. From theſe, and from barren tracts of land, few exhalations ariſe.

4. *According to the nature of the ſoil, and of the earth underneath:* for we cannot expect the ſame exhalations from earth locked up with froſt, as from looſe rich ſoils; nor from the ſame ſoil when chilled by cold, as when warmed by the ſun; nor from lofty and mountainous ſituations, as from plains or vallies; nor from deſarts, as from well-inhabited countries.

5. Laſtly,

5. Laſtly, the air, and the particles with which it is impregnated, differ according to *accidental changes and circumſtances*, which cannot eaſily be accounted for or deſcribed.

SECT. XII.

From the above mentioned circumſtances (Sect. 11.) it will appear, *why the very ſame ſort of vegetables ſhall often not ſucceed equally in one and the ſame climate; and why a plant removed to another place, though in the ſame climate, ſhall decay.*

SECT. XIII.

If we recollect what was ſaid in Chap. I. Sect. 15, 16, concerning the conſtituent parts of vegetables, and at the ſame time conſider that every kind of water may be converted into earth, as has been demonſtrated in the chemiſtry of natural bodies, and as will be more fully noticed in the enſuing chapter; we may ſafely conclude, that *all the elements and materials of which vegetables are compoſed, exiſt in the atmoſphere*; as is likewiſe remarked by BOERHAAVE. *Chem. Tom.* I. p. 410.

SECT. XIV.

Since the *air* and the *atmoſphere* are ſo manifeſtly neceſſary to vegetation, as what we have before

ſaid

ſaid proves, it readily follows, that we may lay down the following principles as indiſputably true, viz. *The more plants enjoy a free acceſs of air to all their parts, not excepting their roots,* the better and eaſier they *grow and thrive.* Hence it is that vegetables ſucceed ſo well in moſs. And, *the more it is proportioned to the nature of each vegetable, both in it's quantity and in it's quality,* the better they will ſucceed.

CHAP. VI.

OF WATER, SO FAR AS IT PROMOTES VEGETATION.

SECT. I.

DAILY experience teaches us, that *vegetables cannot grow without water*; and we find that their growth is proportioned chiefly to the quantity of rain water which they receive. Many antient and modern naturaliſts, ſeeing plants grow in clear water, have from thence concluded, that water is the only food of plants: and on the other hand many, not conceiving how the different parts of which vegetables are compoſed could take their origin from pure water, have conſidered water rather as a *vehicle*, than as the *nouriſhment* of plants. Endeavours have been uſed to ſupport each opinion by experiments, of which I ſhall here give a ſhort account.

SECT. II.

The experiments hitherto made in order to prove that water conſtitutes the real food of plants,

are

are of two kinds: the first relate to *the soils*, and are instituted to determine what they afford; and the others regard *the water only*.

Sect. III.

Van Helmont was, I think, the first who, by a remarkable experiment, shewed that the earth contributed nothing to the nourishment of plants. "I took," says he, page 104 and 130 of his works, "an earthen vessel, and put into "it two hundred pounds of earth dried in an "oven; I moistened that earth with rain-water, "and planted in it a cutting of willow which "weighed five pounds: this cutting produced a "tree, which, at the end of five years, weighed "an hundred and sixty-nine pounds and about "three ounces. The earth was moistened when "necessary with rain or distilled water. The "vessel was large, and fixed in the ground; and "lest any flying dust might mix with the earth in "it, it's mouth was covered with a tin plate "pierced with a number of holes. I did not "reckon the weight of the leaves which fell "during the first four years. At the end of the "fifth year, I dried the earth contained in the

"vessel,

" veſſel, and found it weigh it's firſt weight of " two hundred pounds, wanting only two " ounces."—ROBERT BOYLE made a ſimilar experiment with gourds, with the like ſucceſs.

After theſe, GLEDITSCH and BONNET took a different courſe, and found that vegetables grow *without earth*, provided they have plenty of air and water: for they experienced that plants ſet in *moſs* or *ſponge* kept in glaſſes and moiſtened with water, grew well and flouriſhed: (*Mem. de Mathem. & Phyſ.* Tom. I. p. 420, *&c. Comm. Lipſ.* Tom. I. p. 34, *&c.*): and ſtill more lately, M. DUHAMEL, (*Hiſtory of the Academy of Sciences for the year* 1748, p. 272, &c.) has repeated nearly the ſame experiments, and found, upon an accurate examination and chemical analyſis of plants which had grown in water, that they contained the very ſame parts as other plants of the ſame ſort which grew in earth; from whence he juſtly concludes, that thoſe parts were introduced by *pure water*. He alſo found, that mixing the *water* with *nitre*, *common ſalt*, *fixed alkaline ſalt*, or even with a ſolution of *rich earth* or *dung*, contributed little to promote the growth of plants, and that they thrive better in pure water.

Since

Since that time, G. W. KRAFT has made experiments on the ſame ſubject, a little different from the former, as to their manner, but nearly ſimilar in the event. He ſowed *oats* and *hemp-ſeed* in different ſubſtances, viz. in *rich earth*, in *ſand thoroughly dried*, in *ſhreds of paper*, in *pieces of woollen cloth*, in *chopt hay*: he afterwards moiſtened theſe ſeeds with water, and found that they grew nearly as well in one ſubſtance as in another, excepting only a little difference in point of time in ſome caſes. He obſerved on the contrary, that in *filings of iron*, in *aſhes of plants not waſhed*, in *ſand* mixed with *nitre*, in *pot-aſhes*, and in *flour*; the ſeeds ſown, and treated in the ſame manner, did not vegetate at all.

Laſtly, Dr. ALSTON, of Edinburgh, has made nearly the ſame experiments, with like ſucceſs. *Salts* of ſeveral kinds mixed with earth, not only retarded the growth of plants, but put a total ſtop to it. He found that the moſt *hungry earth, exhauſted by vegetation, and ſifted*, nouriſhed plants full as well as the richeſt earths. He alſo remarked, that the hungry earth became much more barren by being mixed with *lime*, and that *lime-water* did not promote the growth of herbs or ſhrubs.

From

From theſe experiments, made with the greateſt care, repeated with the utmoſt circumſpection, and always attended with the ſame ſucceſs, we are authorized to conclude, *that the earth yields no real nouriſhing matter to plants; but that the whole of their nutritive juices is derived from water and the atmoſphere.*

SECT. IV.

TRIEWALD, in Sweden, in the year 1730, and ſince him ELLER (*Hiſt. de l'Acad. R. de Berlin, An.* 1746, p. 45, *&c.*) have alſo lately confirmed theſe (Sect. 3.) experiments. The latter in particular obſerved, that a *cucumber plant* grew perfectly well in earth, the weight of which was rather increaſed than diminiſhed thereby; and that the *roots of hyacinths* put in diſtilled water, not only produced perfect plants, but, after being burnt, yielded *true earth*. This *tranſmutation of water into earth* having been proved in that part of chemiſtry which treats of natural bodies, it would be needleſs to enlarge upon it here.

SECT. V.

Theſe experiments (Sect. 3, 4.) prove evidently, that *vegetables derive all their conſtituent parts from*

from water, even their oils and ſalts, as well as their earthy particles; as will appear ſtill more plainly from what follows. Four thouſand different plants can grow in twenty pounds weight of earth, and in each of them ſhall be found a different *oil* and a different *ſalt*. Let us ſuppoſe theſe plants to be chemically analyſed; near *an ounce of oil and ſalt* will be found in each. If this *oil* and this *ſalt* had proceded from the *earth*, there muſt have been in that earth four thouſand ounces, or two hundred and fifty pounds of *oil* and *ſalt*: whereas, in fact, there was not a grain of either of them in it.

Sect. VI.

We may clearly ſee from theſe experiments, that plants imbibe a great quantity of water; inſomuch that, the weight of water taken in daily may equal, if not ſurpaſs, the weight of the plant, or of the branch immerſed in it. We muſt not however think that all this water continues in the plants; for *the greateſt part of it exhales*, and they retain only a certain portion of it. Plants which are expoſed to the ſun exhale more than thoſe that are in the ſhade. Both Guettard (*Hiſt de Acad. R. de Paris, An.* 1748, p. 569.), and

Hales

HALES (*Veg. Stat. Experim.* 17.) agree, that the liquor exhaled is pure water, as being without *taſte* or *ſmell*; unleſs the heat be very conſiderable, in which caſe it taſtes a little, and ſooner putrefies. WOODWARD's experiments are to the ſame effect.

SECT. VII.

That we may the more diſtinctly know *wherein water contributes to vegetation*, it is neceſſary to inquire, firſt, what effects water has on *plants*; and ſecondly, what effects it has on *the earth* itſelf.

SECT. VIII.

Water exerts it's influence on plants, and promotes vegetation,

1. *Materially, by furniſhing an abſolutely neceſſary nouriſhment*, which, by means of ſomething *communicated from the air*, generates *earthy*, *ſaline*, and *oily particles* (Sect. 3, 4, 5.); and by it's *fluid unelaſtic ſubſtance's* forming a kind of *glutinous* matter, which, *if it does not entirely accompliſh the union of the earthy particles, at leaſt contributes thereto by means of it's oil:* for part of the water

adheres ſo cloſely to the internal ſolid parts, that it cannot be ſeparated or expelled without a total ſolution or deſtruction of the plant. Seeing therefore that water thus conſtitutes and enters into the mixture of the parts of plants, no one can deny, that, *in it's fluid form*, it is a true material principle of vegetation.

2. Water promotes vegetation *inſtrumentally*, firſt, by ſoftening the *bark* and *membranes* of plants, that ſo their extenſion and nutrition may the more eaſily go on: next, by carrying with it *ſalts and oils from the air*, by means of heat (Chap. V. Sect. 8. N° 2.): thirdly, by promoting the *inteſtine motion* of the fluids excited by heat and the air (Chap. II. Sect. 10, 11.): fourthly, by yielding a *vehicle* as well as *menſtruum* to the ſaline nutritious particles; for by means of the *ſalt*, the oily particles are prepared and mixed with the water, and ſo reduced into a fluid matter fit for nouriſhing the plant: and laſtly, as a *vehicle* for carrying off the *uſeleſs parts* of plants with the ſuperfluous water conſtantly tranſpiring (Sect. 6.)

SECT.

SECT. IX.

Water operates *on the earth itſelf* (Sect. 7. N° 2.), by *looſening* it, ſo that the air may reach the roots of the plants, and they may the better extend themſelves: by rendering it *moiſt*, ſo that the *nutritious* particles (Sect. 3, 4.) may riſe to the roots by evaporation; and by diſſolving the *ſaline* particles that are in the earth, by means of which the *oily* particles are eaſily united with water.

SECT. X.

For water to exert it's nutritive and inſtrumental power in promoting vegetation, it is neceſſary,

1. That it be reduced to the moſt *ſubtile vapour* poſſible; for otherwiſe it cannot enter into the imbibing veſſels of vegetables, as was before demonſtrated (Chap. II. Sect. 4.)

2. That it be of *a fit degree of warmth*, in order that the heat may expand the imbibing veſſels, and that the glutinous and thick ſubſtances may be attenuated: for the veſſels are ſhut up *by cold water, or cold vapours.* It is on this principle of adapting the degree of warmth to the qualities of plants, that gardeners never pour cold water

on plants which delight in warm ſituations, or warm water on plants which grow in cold places.

3. That it be in *a proportion ſuited to each plant:* for water may become hurtful, either *by exceeding,* or *by falling ſhort of,* the due quantity. That we may the more diſtinctly judge of this, we muſt attend to the *waters,* not *only in the earth, but alſo in the air.*

SECT. XI.

Waters which reſt on the ſoil become hurtful,

1. By *exceſs*; for too great moiſture hinders plants from attaining the end of their vegetation, which is, the *perfecting of their ſeeds:* for what ſeeds they produce then, being too full of water, ſhrivel when dried, and are eaſily deſtroyed by too great cold. Hence alſo it is, that wet ſeaſons do not yield the moſt plentiful harveſts. Beſides, too great a quantity of water entering into the veſſels of plants, diſtends them too much, and ſometimes burſts them; and this the more readily, the more the veſſels reſiſt the diſtending force. *Too great abundance* of water likewiſe forms *a vitiated thin food* which either *putrefies* or becomes *acid* by the heat of the ſun, as we ſee in *ſtagnating water:* and ſo

thi

this reaſon it is that ſuch places are barren. To this alſo it is perhaps partly or wholly owing, that plants which grow in lands abounding too much in moiſture, are ſeized with a diſorder reſembling a *mortification* in live bodies; and hence too, probably, ariſes the *roughneſs* and *ſcabbed* appearance of the ſtems and leaves. When land has been *too wet*, even rich ſoils, the marly or clayey, it becomes hard if a drought ſucceeds, and that hinders the roots from *piercing into it*; and laſtly, too much water prevents *the acceſs of air to the roots*. It is evident then, on theſe accounts, that *too great a quantity of water deſtroys the natural progreſſion of the growth of plants, and rather impedes than promotes vegetation.*

2. A *want of water is hurtful*, becauſe the earth becomes *too dry* and burning. Warmth diſſipates the moiſture in the earth, and the earth being as it were baked by the rays of the ſun, burns up the roots of plants. Land which has been *marled*, or improved by *alkaline ſalts*, *lime*, or *dung not ſufficiently rotted*, is moſt liable to this calamity. In ſhort, it neceſſarily follows, that *a want of water will deprive plants of every advantage before-*

mentioned (Sect. 8, 9.) *as arising from the due quantity of water.*

Sect. XII.

1. *Excess of rain*, or of *water from the atmosphere*, is hurtful, because *it lessens the warmth in the earth, and in the vessels of plants:* and hence it is that, in very rainy seasons, plants do not grow; but instead of that deep green which denotes their healthy state, become of a pale colour, and rather diminish in size, especially if the rain is attended with cold, whereby their fibres are contracted. The earth is rendered so loose, that *the roots have no firm steady holding. The stems are so much weakened*, that they are apt to *fall*, especially when they are grown large and in rich fields, whereby the seed, and indeed the whole plant, is hurt and rotted; and *if these rains fall when the plants are in bloom, their farina is washed away*, so that there is no impregnation, and consequently no grain.

2. Whoever considers the *utility of rain* (Sect. 8, 9.) in due quantity, for promoting of vegetation, will be sensible that the *want* of it, by depriving plants of all the benefits of that water, must be *highly prejudicial.*

It

It may perhaps be alledged from what has been here ſaid, that *if water is the ſole food of plants, no land can ever become barren.* But this objection cannot be properly anſwered, till we ſhall have ſhewn what advantages ariſe from *culture*, and other means of enriching the earth.

CHAP. VII.

OF EARTH, SO FAR AS IT PROMOTES VEGETATION.

SECT. I.

IT will appear from the following conſiderations, that *no mineral earth* (that is, earth newly dug and unmixed with any heterogeneous matter) *inters as a nouriſhment into plants*; *1ſt*. Becauſe *the earthy particles of plants*, however ſeparated, are of an *entirely different nature* from mineral earth (Chap. I. Sect. 5.): *2dly*. Becauſe earth is *indiſſoluble* in every kind of water; and unleſs diſſolved, it cannot be put in motion, and much leſs enter the abſorbing veſſels of plants (Chap. II. Sect. 4.) Hence we may conclude, that *earth, merely as earth, does not in any manner yield nouriſhment to plants*.

Remark. Mr. JETHRO TULL was the firſt who maintained the contrary opinion, in which he has been ſupported by M. DUHAMEL DU MONCEAU (*Traité de la Culture des Terres*), and others, who think that earth is

is the principal food of vegetables. Lord BACON's opinion is more natural, that *earth ſerves only as a ſupport to plants, and to defend them from heat and cold.* It is now well known, that plants which have not any communication with the earth, are nouriſhed by their *leaves*, the ſame as by their *roots*.

SECT. II.

Experience however teaches us, that *plants thrive better in ſome kinds of earth than in others*; owing to the different qualities and nature of the earths, whether too *ſtiff* or too *looſe*; and likewiſe to the variety of ſubſtances mixed with the earth, whence it becomes *fruitful* or *barren*.

SECT. III.

Earth is ſaid to be *ſtiff* or *ſtrong*, when it *adheres cloſely together*, and is of a *conſiderable depth*. This earth retains the rich particles mixed with it, and reſiſts the cold, drought, and other injuries of the air. A *looſe earth* is, on the contrary, in general, *more ſhallow*, and, owing to it's *ſlight coheſion*, the rich or watery particles mixed with it eſcape, nor can it reſiſt the injuries of the air.

Remark. In forming a judgment of earth, it is highly neceſſary to attend to the *depth of the layer*. The ſoil is ſaid to be *deep*, when a layer of clay or other ſtrong earth reaches to the depth of four, five, or more feet; and to be *ſhallow*, when ſuch earth is of only a foot or two feet deep, over a bed of ſand, gravel, or ſtone.

SECT. IV.

Earth is ſaid to be *fruitful*, when it is ſtored with a due quantity of the particles ſuited to become the nouriſhment of different plants; and to be *barren*, when it contains none or few ſuch particles. *Barren earth may therefore be rendered fruitful*, by mixing with it ſuch particles as are found to yield nouriſhment to plants.

Remark. From this idea of fruitful and barren earths it appears, that fertility does not depend on any *peculiar* kind of *earth*, ſuch as the *rich black mould*, as ſome have thought; but only on a due mixture of heterogeneous ſubſtances adapted to that purpoſe.

CHAP.

CHAP. VIII.

OF MOULD, SO FAR AS IT CONTRIBUTES TO THE GROWTH OF VEGETABLES.

SECT. I.

MOULD is almoſt every where ſpread to a greater or leſs depth on the ſurface of the earth, is generally of a blackiſh colour, and enlarges in bulk *by the addition of water*, whereby it becomes *looſe* or *ſpongy*, and when dried, *harder, and falls readily into powder*. Water ſeparates eaſily from it, either by *eſcaping* through it, or by *evaporation*.

I ſhall conſider the properties of this mould only ſo far as it is perceived *to promote vegetation*.

SECT. II.

This mould being *diſſolved in water, in a mild heat*, and the *infuſion* afterwards evaporated, there remains *a yellowiſh powder* of *a ſaline taſte*. If a *ſtronger heat* is uſed, the extract is of a *darker*

colour, and, when thickened by heat, it has an *acrid ſmell and taſte*: but if the extract is evaporated to dryneſs, there remains *a ſaline glutinous* matter, ſoluble in water, which is the *unctuous magma* deſcribed by KULBEL in his *Diſſert. de cauſa Fertilitatis. Theſ.* XI, XII, &c.

Remark I. J. A. KULBEL, in the above-mentioned treatiſe, would fain demonſtrate that this *unctuous magma* is the ſole cauſe of fertility: in regard to which we muſt obſerve, 1ſt. That this *magma*, is of ſo adheſive a quality that it cannot enter into the pores or veſſels of plants, as is obſerved by LUDVIG in his *Tr. de Terris*. If *milk* and *honey* cannot enter into the pores of vegetables, as appears from G. W. KRAFT's experiments in the *Memoirs of the Academy of Peterſburgh*, Tom. II. p. 231; much leſs can this *magma*. It ſeems to be that *glutinous matter* by which the terreſtrial particles and fibres of vegetables, of which the mould is compoſed, are glued together and we ſhall call it a *glutinous ſaline matter*.

Remark II. The *ſaline matter* found in the extract appears, by KULBEL's experiments and thoſe of others, to be ſometimes *alka-*

line

line, ſometimes of the nature of *ſal mirabile*, and ſometimes of that of *nitre*; but there is always joined to it a *muriatic ſalt*. Theſe ſaline particles ſeem all to be only *accidental* gueſts in the mould.

SECT. III.

Mould yields *by diſtillation*,

1*ſt*. *Phlegm*, in quantity proportioned to the moiſture of the mould.

2*dly*. A ſharp empyreumatic *ſpirituous* matter, of a dark colour, reſembling *ſpirit of tartar*.

3*dly*. A red *oily* ſubſtance.

Remark. It appears from hence, that mould derives it's origin from decayed vegetables; for no *glutinous* (Sect. 2.) *ſpirituous*, or *oily* matter is found in the mineral kingdom; and the *unctuous magma* ſeems to proceed from the oily matter obtained by diſtillation.

SECT. IV.

Mould, as above deſcribed, does not always remain the ſame; for, expoſed to the ſolar heat, it loſes it's rich *oily* particles, together with the *watery vapours*, with which they are cloſely combined;

bined; and thus the mould is left *a naked earthy powder*. In *moiſt* places, and in the neighbourhood of waters, it loſes little or nothing, but is rather annually increaſed by the roots and plants which putrefy in it. This is the origin of *turf* or *peat* earth, where the mould is as it were ſuffocated with water.

Remark I. Experience has proved that land enriched with *cut turf* does not retain any advantage from it longer than two years, in reſpect to fertility; and therefore ſcarcely compenſates the loſs of the graſſy ſurface taken away with the turf. The turf is of the greateſt advantage when laid on *clay*, which it renders more ſoluble.

Remark II. They who think that *mould is changed into clay*, have not ſufficiently attended to the original qualities of each.

Sect. V.

This mould contributes greatly to promote vegetation;

1*ſt*. *Materially*, by adminiſtering it's *rich ſaline juices* for the nouriſhment of plants, theſe laſt being neceſſary to render the oily particles miſcible with water. Theſe rich ſaline juices are eaſily

ſeparated

ſeparated by *heat* and *water* (Sect. 2, 4.); to prevent which, the mould ſhould be mixed with *clay*.

2*dly*. *Inſtrumentally*, by attracting and retaining the oily particles in the air, which thereby aſſociate the more ſtrongly with homogeneous bodies.

3*dly*. By it's looſe ſtate and ſolubility it admits the *air* to the germinating ſeeds, and to their roots; without which circumſtance vegetables can ſcarcely grow, as was before demonſtrated (Chap. V. Sect. 14.).

4*thly*. *It is eaſily kept in tilth.*

Remark. It is to be obſerved of the fertility which depends on mould, 1*ſt*. That *every kind of mould is not equally fertile*. That which lies in *ſhady* places is generally *richer* than what is expoſed to the heat of the ſun. 2*dly*. The *acid* which accidentally adheres more or leſs to ſome ſorts of mould, is of *two kinds*; the one of a *vegetable* nature, ariſing from vegetables, or rather ariſing from *ſtagnating water*, which is diſſipated by expoſing the mould to the heat of the ſun; the other of a *mineral* nature, which is not diſſipated by drying it in the ſun, and ariſes from waters brought to it charged with ſuch

acid. It is either of the *vitriolic* kind, ſuch as is found in turf or peat-earth in mountainous places, and which when expoſed to a ſtrong fire, is only turned into a coal, and does not eaſily take fire; or it is of the nature of *ſea ſalt*, ſuch as is found in turf bordering on the ſea. It is therefore no wonder that chemiſts have obtained different acids from turfy mould, as appears from the experiments of HIÆRNE, in his book *de Terra*; of KULBEL, in the place before quoted; of LIND, in the *Edinburgh Philoſophical Tranſactions*; of DUPRÉ d'AULNAY in the *Journal Oeconom.* and hence the diverſity of opinions on the utility of turf. *3dly. Turf impregnated with the vegetable acid*, or with that occaſioned by *ſtagnating water*, is found to be of great uſe *in impregnating ſoils*, provided all it's rich particles be not waſhed away, which is the caſe when the turf is often alternately over-flowed and dried. The *acid turf* ſhould be deprived of it's *acid* before it is uſed. The turf which is impregnated by the *mineral acid*, appears to be leſs uſeful. Hence it is clear, that huſbandmen and others who have written

written on mould and turf, and have praiſed or diſpraiſed them in general, have erred; ſeeing they are found to be ſo different, according to the ſituation of places.

SECT. VI.

Mould, though pure and free from every heterogeneous matter, yet has it's *inconveniencies*.

1*ſt*. *In dry years* it becomes *too looſe*, ſo as to let all it's moiſture eſcape by evaporation, and it thus eaſily loſes all it's richer particles (Sect. 4.)

2*dly*. As it is very *elaſtic*, it ſwells by admitting water, and is *contracted* in bulk, and *compreſſed* when deprived of it: hence ſeeds do not find in it a *firm ſettlement*, without which vegetation is languid and interrupted. It may alſo happen that the root may be torn to pieces, if it is unequally expanded or contracted.

3*dly*. If it is in a *looſe* ſtate, it cannot be eaſily *frozen* into one maſs, but rather into ſmall pieces; by which means the roots of plants are eaſily torn aſunder, and the cold is admitted to them; and hereby this ſoil is expoſed to great dangers.

4*thly*. It is eaſily changed into a *barren earth* (Sect. 4).

Remark. From this account we may judge of the great commendation beſtowed on this earth

earth by many writers on huſbandry, and particularly PLINY. It is peculiarly proper for *gardens* in which (as in Sweden) ſeeds are not ſown till ſpring, and the ground is *watered* if neceſſary. The Engliſh have judged right in turning this rich mould into *paſtures* and *gardens*, rather than into *arable* land. It is obſerved, that plants growing in mould run more to *leaves* and *ſtalks*, than to *ſeed*; though this happens only when the mould is too rich and too moiſt.

CHAP.

CHAP. IX.

OF CLAY, SO FAR AS IT IS CONCERNED IN VEGETATION.

SECT. I.

CLAY is a *tough earth*, feeling *fat* to the touch, *ſticking* to the fingers when *moiſt*, of a *ſtrong and denſe conſiſtence*, and compoſed of *exceeding ſmall particles*. The clay however which is found on the ſurface of the earth is greatly *mixed*, either with *mould*, *ſand*, or other heterogeneous particles, ſo that it differs much in it's tenacity, as well as in it's other properties.

SECT. II.

The chief *properties of clay*, which come under our conſideration here, are,

1*ſt*. That it not only *attracts water*, *collects and retains it*, but that, when *mixed therewith*, it becomes a *tough paſte* which takes any form from the hands. It ſcarcely tranſmits water, and lets it eſcape only by evaporation: it is therefore the chief means of preſerving the ſubterranean moiſture; and

and on this account it is always moiſt at a depth under ground, and becomes a ſource of ſprings.

2*dly*. That *in hot air*, as *by fire*, it becomes *dry* and *hard*, and forms on the ſurface *a ſtrong cruſt*, which opens into *cracks* or *rents*, the larger the more the clay is mixed with ſand, or altered by other heterogeneous mixtures.

Sect. III.

In *a warm ſolution of clay in water* no *ſalt* can be ſeparated from it, unleſs ſome has been by accident mixed with it. A little *ſea ſalt* is ſometimes obtained from it, as appears from Hiærne, *Tent. Chem.* I. and ſometimes a ſmall portion of an *alkaline ſalt*, as in Kulbel's experiments, *Theſ.* XXV. We may conclude from this diverſity, that ſalts are mixed with it only by accident, and that they do not contribute in any degree to the eſſence of clay; for in a ſubſequent ſolution, the clay remains the ſame as before, equally tractable, and equally ready to imbibe water.

Remark. The clay which is found deep in the earth, is always purer than what is found on the ſurface: hence alſo it appears, that whatever *ſalt* is in it, comes from either *rain* or ſome other *water*.

Sect.

SECT. IV.

By *diſtillation* clay yields,

1*ſt. Phlegm*, which however is very different, ſome being perfectly *pure* from clays, containing ſomewhat of an *urinous ſmell* in others, and having in others again ſomewhat of an *acid nature*; eſpecially in clays which are found in hilly countries, which have been very long expoſed to the air, or which have been penetrated with rain or ſnow-water.

2*dly.* Somewhat of a *ſalt* is ſublimed (or ſettles on the head of the ſtill), which is either of the *ammoniacal*, or of the *urinous* kind. HIÆRNE, *Tent. Chem.* 1. POTT, *Lithog.* p. 1. NEUMAN, Vol. IV. p. 1. JUNCKER, *Conſp. Chem.* Tom. I. p. 284.

SECT. V.

No *oily* or *unctuous* matter can be obtained from clay, either by ſolution (Sect. 3.), or by diſtillation (Sect. 4.). We grant that there is an oilineſs in it when combined with ſalt (Sect. 4.); and that by making a ſtrong extract of it, ſome little may be obtained, as ELLER endeavours to ſhew in the *Memoirs of the Academy of Berlin*; but in ſo ſmall a quan-

a quantity, that it ſcarcely deſerves mentioning; and we may therefore, in our preſent inquiry, conſider it as deſtitute of oil.

Sect. VI.

As *oily and inflammable particles* enter into the very idea of a *gluten*, ſo it appears that there is no *gluten* or *magma* in clay; nor have the contenders for that opinion been able to ſhew that there is any ſuch. It's tenacity, and it's being ſo eaſily moulded into any ſhape, muſt therefore depend on it's attraction of water, and on the attraction of it's particles to one another (Sect. 2.).

Sect. VII.

Clay becomes *hard* when continued long in heat (Sect. 2.): it is therefore no wonder that, in a natural heat, and other cauſes at the ſame time concurring, it acquires a *ſtrong hardneſs*, or is *converted into real ſtone*.

As clay cannot loſe it's tenacity and tractability but by ſtrong fire, or the application of very corroſive mineral acids, as is demonſtrated by chemical experiments; we doubt much whether it can become a looſe earth by any natural or ſpontaneous change.

Remark.

Remark. There are ſome ſpecies of clay which are leſs tough than others, and are therefore called *ſhort*, or *trippellaceæ* (i. e. compoſed of three kinds); whoſe ſolubility depends on the mixture of *heterogeneous matter*.

SECT. VIII.

Clay *conduces to fruitfulneſs*, not *materially*, for it contains nothing *oily* or rich (Sect. 5.); but *inſtrumentally*, and that,

1*ſt*. Not only by attracting *water and ſubterraneous vapours and oils*, but alſo by collecting and keeping them longer under the *cruſt*, occaſioned by drought (Sect. 2. N° 2.), than any other earth does, and not letting them eſcape any way but by evaporation. It is for this reaſon that plants can live and grow beſt in clay during a dry ſummer (Sect. 2.); and hence this is juſtly called *a ſtrong earth*.

2*dly*. The *rich particles* introduced into clay from *dung* or *manures* of any kind, or dropt from the *air*, cannot be diſſolved and waſhed away by rain (Sect. 2.).

3*dly*. The air and whatever it contains has acceſs to the roots of plants by the *cracks and*

crevices

crevices with which clay abounds in dry weather*.

4*thly*. *Mould mixed with clay*, or *generated* by acceſſion of new matter, retains it's richneſs longer (Chap. VIII. Sect. 6. N° 1.), being compreſſed by it's weight. and thoroughly mingled with it (Sect. 2. N° 2.)

5*thly*. The *winter*'s *cold* reaches the roots of plants equally; as clay does not freeze in ſmall pieces, but into a large *coherent maſs* in land laid flat.

6*thly*. As it continues conſtantly the ſame with regard to it's properties, neither *drought* nor *much wet* prove prejudicial to it (Sect. 3, 7.)

Sect. IX.

Clay is *hurtful*,

1*ſt*. By it's *tenacity* and *toughneſs* (Sect. 2. N° 1.), which qualities equally prevent the eaſy entrance of water or improving particles, and exclude the air from the germinating *ſeeds* and roots of plants, whilſt its moiſture hinders the acceſs of warmth, and prevents it's action; for which laſt reaſon farmers call it a *cold ſoil*.

2*dly*. By it's *hardneſs* in dry weather (Sect. 2. N° 2.), which prevents the extenſion of the roots,

* The huſbandry muſt be bad where this is the caſe.

whereby

whereby they are deprived of their nouriſhment, which is locked up in the hardened earth.

3dly. By the loſs of the remaining moiſture, which evaporates through the *cracks* (Sect. 2. N° 2.) when the *drought* continues long, and by the tearing of the roots which croſs the cracks, which alſo, if not cloſed by the autumnal rains, admit the *froſt* unequally in the winter; and,

4thly. By the difficulty of cultivating it: for it is rendered too ſoft by wet, and is poached by the plough into a paſte; and may be afterwards dried into ſo large clods by a ſubſequent drought, that they can ſcarcely be divided or broken up by the plough.

From theſe inconveniencies we may underſtand why very few plants can grow in *pure clay.*

Remark I. *The advantages and diſadvantages attending clay vary according to the differences of the clay:* for the more the particles of the clay are ſeparated by the mixture of heterogeneous matter, ſo much the leſs will it retain water and the manures mixed with it; and ſo much the leſs alſo will it be hardened by heat and drought. It will therefore be the more eaſily cultivated, and

better nouriſh plants; air and the neceſſary heat having freer acceſs to it.

Remark II. A clay in which an *acid* abounds is leſs fit for culture, becauſe the water contracts an acid quality, and is led by the acid into it's ſubſtance, as through channels.

CHAP.

CHAP. X.

OF CHALK AND LIME, AS CONTRIBUTING TO FERTILITY.

SECT. I.

THOUGH we have but little chalk and lime in this northern region *; yet, as the uſe of lime eſpecially is extolled to the ſkies, it is neceſſary that we inquire into their natures ſo far as they contribute to fertility.

Remark. Though chemiſts obſerve a difference between chalk and lime, yet it is ſo little that, with reſpect to fertility, we may conſider them as of the ſame qualities †.

SECT. II.

Chalk and *lime* abſorb water poured upon them, and let it ſpeedily paſs through them: but in an extract of them made with water, ſomewhat of

* *Viz.* Sweden, where the author wrote.

† N. B. Our author ſeems, through the whole of this chapter, to ſpeak of calcined lime-ſtone.

the chalk and lime is diſſolved in that water, thence called *lime-water*, which effervesces with acids, and is a powerful *ſolvent* of *pinguid* and *ſulphureous* bodies.

Experience teaches, that the mixing of lime with water *quickens their evaporation*, which may be imputed to the greater degree of heat which lime-water receives.

Sect. III.

By *diſtillation*, *chalk* yields only a little *volatile ſalt:* but if water is mixed with it in ſuch proportion as to render it of the conſiſtence of a poultice, and the maſs is then diſtilled, a water is obtained which partakes of the nature of chalk, and ſhews ſome ſigns of an *alkali*. *Lime* diſtilled by itſelf yields no ſalt; but if it is diſtilled with *water*, a *water* is obtained of a calcareous taſte, with ſome ſigns of an *alkali*.

There is therefore in chalk and lime a ſomewhat *miſcible with water*, and which *evaporates with it*. This is very perceivable in new-built ſtone houſes, both by the ſmell and other effects.

Sect.

Sect. IV.

Chalk and lime *effervesce* when mixed with *acids*, and absorb them; and if the mass is distilled, an insipid phlegm comes over it. What remains after the distillation can scarcely be dried; so strongly does it *attract the moisture of the air*.

Sect. V.

No *oily* matter can be obtained from chalk or lime, either in an *extract* (Sect. 2.), or by *distillation* (Sect. 3.) They however possess a strong power of *dissolving every oily substance*, especially if *water* and *warmth* are added (Sect. 2.) There is in them even an *attraction* to such substances.

Sect. VI.

Lime attracts *oily* and *gelatinous* mixtures, and *coagulates* and *hardens* them when mixed with them. When mixed with *clay* or *sand*, it likewise becomes *hard*, as every one knows.

Remark. If the unctuous matter found in the earth was the food of plants, as Külbel thinks; and if he had duly considered the properties of lime he could not have praised lime so much as he has done (*Thes.*

30.) for it's power of *dividing*; ſeeing that unctuous ſubſtances are rather *coagulated* by it.

SECT. VII.

From the above account of chalk and lime, we may conclude, that they are beneficial to ſoils,

1*ſt*. *Not materially*, ſince they contain nothing unctuous. Many are of opinion that *calcareous earths* enter as *nouriſhment* into plants: but no ſuch earth has ever been found in any of the kinds of corn that are uſed for eating, nor in any of the ſmaller vegetables; and as to the calcareous earth which is obtained from the more ſubſtantial vegetables, it is very different from either chalk or lime (Chap. I. Sect. 5.)

2*dly*. They are however inſtrumentally of *uſe* both to the *ſeeds* that are planted, and to the *land*;

1*ſt*. By attracting the *acid* and *oils* out of the atmoſphere;

2*dly*. They give *a greater warmth* to the earth and water, being ſtrongly attractive of every inflammable ſubſtance (Sect. 2, 5.);

3*dly*. They reſolve *unctuous ſubſtances* and *water* into vapour, by means of heat (Sect. 2.);

4*thly*

4*thly*. *Lime accompanies watery vapours* (Sect. 3.), and may by that means *enter into the ſeeds of vegetables*, and there reſolving *oily* particles (Sect. 5.), and deſtroying the *acid* in thoſe ſeeds (Sect. 4.), promote that *ferment* which is neceſſary in germination (Chap. III. Sect. 6.) to bring on a due degree of ſweetneſs.

Remark. Many uſe lime ſucceſsfully in promoting the vinous fermentation, without attending to it's manner of acting. Dr. ALSTON of Edinburgh is of opinion, that lime-water does not afford nouriſhment to the roots of vegetables, nor promote the growth of plants; but this is to be underſtood of lime-water when uſed alone, without any other nouriſhing ſubſtance.

5*thly*. They deſtroy and abſorb the *acid* in the earth; and thus may deſtroy *inſects*, which harbour moſtly in acid earths: but whether they deſtroy *weeds* by this quality, we cannot ſay.

6*thly*. They reſtore *unctuouſneſs* to the land, and by attenuating it's *oily particles*, render them fitter for *mixing with the circulating fluids*.

7*thly*. *They render the tilth of the land more eaſy*.

Remark. If it be true that *ſeeds are rendered larger by the uſe of lime*, and that it takes away *ſmut* (*Act. Reg. Acad. Stockh. ann.* 1741), theſe effects muſt be deduced from the action of the lime: for *ſmut* does not proceed from inſects, but from a ſharpneſs of the *oily particles*, which burn, as if fire had been applied; and therefore it is that the ſmut is *contagious*: for when this *ſharpneſs*, which ariſes from *acid*, is taken away, the diſtemper ceaſes.

SECT. VIII.

Chalk and lime are not leſs *hurtful* to vegetation; for,

1*ſt.* *By raiſing too great a heat*, they almoſt *burn* the ſeeds and roots of vegetables; and therefore it is that calcareous earths are called *burning ſoils*. Hence it is no wonder if, as Dr. ALSTON obſerves, *poor* ſoils become worſe by being mixed with lime.

2*dly.* *By quickening evaporation*, they dry the ſoil too much; by which means plants are deprived of their watery food.

3*dly.* By adhering to the coats of ſeeds, they often cloſe up the pores of thoſe ſeeds; and by *hardening*

hardening their coats, prevent the admiſſion of nouriſhment.

4*thly.* They ſpeedily reſolve and conſume the *richneſs of the ſoil:* whence the obſervation, that *liming enriches only old men.*

It appears from the above, that lime and calcareous earths neither are, nor can be the food of plants; though they are of great uſe to land, if duly and judiciouſly applied, eſpecially in *mixture* with rich manures, or in a *liquid form.*

Remark. It would be needleſs to give here the various and very different opinions concerning lime as a manure; it being ſufficient to obſerve, that caution is neceſſary in the uſe of it. It ſeems evident that it is moſt ſerviceable in *cold* and *ſour grounds*, if uſed in proper quantity; and that if it is laid on *clay together with ſand*, the whole may acquire a ſtony hardneſs.

CHAP. XI.

OF MARLE, AS CONTRIBUTING TO FERTILITY.

SECT. I.

MARLE, which is a kind of compoſition of clay and calcareous earth, and therefore partaking of the nature of both, is ſcarcely ever found on the ſurface of the earth. As both antients and moderns have commended it in the higheſt terms, it is neceſſary that we ſay ſomething here of it's application to land.

SECT. II.

All marle, *when put into water, falls ſooner or later to pieces*, even though of a ſtrong hardneſs when dug up. In the air, it moulders into a powder. It agrees with clay in attracting and retaining water, but leſs forcibly. If marle is calcined, it ſhrinks and becomes more compact, but afterwards it *attracts water* more ſtrongly than ever, and in the air it falls to powder as before.

SECT.

Sect. III.

By a *ſolution* in water, no *ſalt*, nor any thing of an *unctuous* nature can be obtained from it. We boiled ſome of it long in water, but the filtered decoction made no alteration in the colour of *ſyrup of violets*, nor did it precipitate *mercury* diſſolved in *aqua-fortis*. After having been long mixed with it, a little of the *ſublimated mercury* ſubſided, of a *whitiſh colour*.

Remark. If Külbel could extract ſome of the *unctuous magma* from marle (Chap. X. Sect. 3.), it muſt certainly have been mixed therewith *by accident*.

Sect. IV.

By *diſtillation*, no *unctuous* or *oily* matter can be obtained from marle, nor does water diſtilled from it partake of it's nature in any reſpect.

Remark. If marle does not ſhew the leaſt ſign of *unctuouſneſs*, neither by *decoction*, *diſtillation*, ſolution in *ſpirit of wine*, or with *nitre*; I know not on what principle, or by what experiment, many, indeed almoſt all farmers, can maintain it's being in marle.

This notion of marle's being indued with an *unctuous quality* ſeems to depend wholly on it's *ſoft touch*, proceeding from the extreme ſmallneſs of its component particles. The ſame may be ſaid of the *fecundating ſalt*, which others ſuppoſe to be in marle, but never could obtain from it.

SECT. V.

Marle efferveſces with every kind of *acid*, and therefore attracts and abſorbs them; but it does not entirely deſtroy the acids, nor do they make a perfect ſolution of the marle. Two drams of marle being boiled in two ounces of *aqua-fortis*, only twelve grains of it were diſſolved. The *aqua-fortis*, being poured off, efferveſced with a ſolution of alkaline ſalt. What remained of the marle felt like a powder or ſand.

SECT. VI.

Marle diſſolves all kinds of *unctuous* matter, and attracts them: hence it's uſe in taking greaſy ſpots out of cloaths. The fineſt marle is uſed as *fuller's earth*.

SECT.

SECT. VII.

Marle contributes to fertility,

1*ſt. Not materially*, for it is void of every unctuous and ſaline matter (Sect. 3. *Rem.*);

2*dly.* But *inſtrumentally* it promotes vegetation;

a. By *attracting* the moiſture, acid, or oils in the atmoſphere (Sect. 2, 6.), which enrich the land.

Remark. As this quality becomes ſtronger by burning (Sect. 2.), we ſee how wiſely the Engliſh act in uſing it calcined on their grounds. It alſo appears, that the more frequently it is turned, the better effect it has.

b. It promotes vegetation, by *deſtroying the acid* actually in the land, or *removing* that which it might be in danger of imbibing from ſtagnating water; and hence alſo it may perhaps help to prevent a too acid diſpoſition in the ſeeds.

c. By diſſolving every unctuous ſubſtance in the land, whence ariſes a ſaponaceous mixture ſoluble in water, and fitted to enter into the pores of vegetables.

d. By

d. By deſtroying the toughneſs of ſtrong ſoils; for by it's quickly crumbling in the air, the coheſion of a clayey ſoil is diminiſhed, it is rendered eaſier to cultivate, and fitter to carry on the growth of plants.

e. It gives greater ſolidity and firmneſs to looſe or ſandy ſoils; and, as before obſerved, it contributes to their fertility by attracting into this dry ſoil the *nutritive contents of the air*.

Remark. There are ſome who think that marle ſhould not be laid on ſand: but experience has taught the Engliſh to judge otherwiſe.

Sect. VIII.

Marle hurts by a too long and too plentiful uſe of it; for,

1*ſt*. From it's *calcareous quality* it much reſembles *lime*.

2*dly*. It ſoon *diſſolves* and *conſumes* the *fat* of the land.

3*dly*. It looſens a *clayey ſoil*, ſo as that it ſhall be leſs retentive of water.

Marle is however very different, according to it's being more or leſs calcareous or clayey; and therefore

fore it appears, that judgment is more or leſs neceſſary to adapt it to the nature of the ſoil. PLINY (Lib. XVII. c. 7.) recommends it chiefly for *wet and cold ſoils*; and many farmers have obſerved, that it is moſt uſeful when mixed with rich manures.

CHAP.

CHAP. XII.

OF SANDY AND GRAVELLY SOILS.

SECT. I.

SAND and *gravel*, which conſiſt of a ſtony powder, or exceeding ſmall ſtones, have no coheſion of their parts, whether wet or dry.

Remark. There is a kind of *gravel* which country people make uſe of as mortar; but on trial, this appears to have in it a mixture of *clay*, which may be waſhed away; of *calcareous* particles, as appears by it's effervescence with *acids*; and of *chalybeate* particles, which *aqua regia* extracts; whence it appears, that this gravel is a *natural mortar*.

SECT. II.

As ſand and gravel are vitriable, they give way to no menſtruum. Neither *water*, nor the moſt *corroſive menſtruums* can ſeparate any thing from them.

Remark.

Remark. Some kinds of gravel become *adheſive* on the addition of water; owing to a mixture of clay, as already obſerved; and on drying them they become very hard; which circumſtances can be applied only to the above *mortar* (Sect. 1.)

Sect. III.

Sand and gravel do not contribute at all to vegetation, neither *materially*, as nouriſhment, nor *inſtrumentally*, unleſs by *accident*, by the mixture of other earths. They indeed,

1*ſt.* Render *ſtrong earths* more porous and looſe.

2*dly.* They render *ſpongy turf* more ſolid; and hence it is that we find that the ſlime left in low places becomes ſtronger by the mixture of ſand; the ſand and ſlime uniting into a more ſolid earth.

3*dly.* They admit the *air* to the roots of plants; and,

4*thly.* *They facilitate the culture of the land.*

Remark. Some think that *flints and ſtones* render the earth more fruitful, *from a ſalt contained in them*: but they are much miſtaken. Flints and pieces of ſtone may become uſeful, from the ſhade they yield; eſpecially if,

if, by riſing above the ſurface, they pro-
tect the plants from the heat of the ſun
or, as water cannot enter them, all the rain
that falls upon them goes to the plants and
their roots: and hence it is that graſs looks
ſo thriving around ſtones, provided there is
a ſufficiency of earth.

SECT. IV.

Gravel and ſand become rather *hurtful*,

1*ſt*. *By heating too much*; for ſtones being denſer than the earth retain the heat longer, and are ſometimes ſlower in admitting the cold.

2*dly*. They render the ſoil *too looſe*, whence water and the richneſs of the earth are ſoon loſt, either by ſoaking through, or by being evaporated: and hence they eaſily admit cold to the roots of plants.

3*dly*. Becauſe of their *hardneſs*, they attract little or no moiſture or other matter from the atmoſphere; ſo that neither mediately, nor immediately, can they in any way contribute to the nouriſhment of plants.

Remark I. What has been above ſaid ſhews, and experience proves, that ſand is uſeful in *wet and cold ſoils*; and hence it may be concluded, that ſuch ſoils may be uſefully laid on ſand.

Remark

Remark II. *In judging of land*, a particular regard muſt be had to the *ſtrata* or layers underneath. The upper layer is ſometimes poor, when there is a richer ſoil beneath it; and at other times the upper ſurface is more friendly to the growth of plants, than what is met with lower down. What has been here ſaid of the uſe, or of the advantages and diſadvantages of the ſeveral ſoils, muſt be underſtood only of the *upper layer*, *conſidered by itſelf*; knowing at the ſame time, that the upper layer may be rendered better or worſe by a mixture with the lower, according to the different qualities of each.

CHAP.

CHAP. XIII.

OF SALTS, AS PROMOTING VEGETATION.

SECT. I.

MANY, both antient and modern writers on husbandry, have ascribed to salts a very great efficacy in promoting vegetation; being of opinion, though ill founded, that salts not only contribute to the nourishment of plants, but also that the fruitfulness of the earth is entirely owing to them. We shall now inquire how far this opinion is just, either of particular salts, or of salts in general.

SECT. II.

That *no salts whatever afford nourishment, or can of themselves facilitate vegetation*, we conclude,

1. From KRAFTIUS's Experiments, in *Nov. Comment. Act. Petrop. Tom.* II. He planted seeds in sand thoroughly dried, moistened them with plain water, and found that they germinated on the

the *fifth day*, as well as if they had been ſown in ich mould. He put into another veſſel dry ſand ixed with *ſea-ſalt*; into a third, dry ſand mixed ith *nitre*; and into a fourth, dry ſand mixed ith *pot-aſhes*: each of theſe veſſels was watered s much as the firſt, but in vain, for none of the eeds vegetated. ALSTON experienced a ſimilar vent; for ſalts of ſeveral kinds mixed with earth, ot only prevented the growth of plants, but auſed them to periſh (*Tiroc. Both.*). This is arther confirmed by ſome of BONET's experi- ments (*Inquiry into the Uſe of the Leaves*): from ll which it appears, that pure water, without any alt, or that which has the leaſt quantity of ſalt in , is the beſt food of plants; but that when it is ixed with any acrid or ſulphureous ſubſtance, ith urine, milk, ſpirit of wine, &c. it hinders he increaſe of plants. Thus it pleaſed GOD, that he poor alſo ſhould have their aliment.

2. *From the nature of vegetables*, in which no *ineral ſalt* is found (Chap. I. Sect. 6.), except n ſome marine plants, in which a little *ſea-ſalt*, r *ſal mirabilis*, is met with: for the ſalts which re found in ſome vegetables are of a very different ature. But in *bread-corn*, which is the ſubject

here chiefly treated of, we never could find the leaſt veſtige of any *ſalt*, though we made many experiments with that view. Beſides, if ſalts are not neceſſary in the compoſition of the fibres of plants, it naturally appears, that vegetables cannot live better on ſalts than animals can.

3. *From the nature of mineral ſalts*, which we know are indued with a power of *hardening*, rather than of *nouriſhing*. PLINY was long ago convinced of this: however, that no doubt might remain, we diſſolved ſome *nitre* in water, that being much vaunted for it's power of fertilizing, and in the ſolution we put ſome ſeeds of vegetables; by which means we could obſerve, that the ſeeds did not ſwell in the leaſt, much leſs germinate, but rather grew *harder and harder*. Hence likewiſe *fleſh ſalted* becomes always harder. Salts can no more be aſſimilated to the nature of vegetables, than to the nature of animals, through whoſe bodies they either paſs unchanged, or mixed with the juices; they remain immutable *.

4. *From the coldneſs* which the milder ſalts, eſpecially *nitre* and *ſea-ſalt*, give to *water* and *earth*; whence not only evaporation is diminiſhed, but the

* The Tranſlator doubts this fact.

pores of vegetables are contracted and rendered narrower than they ſhould be; for which reaſon they muſt rather retard than promote germination.

5. It appears *from ſeveral obſervations*, that vegetables thrive leſs in places impregnated with *any ſalt*, as is remarked in ſome low grounds, in which the earth abounds with *neutral ſalts*, and near *acidulated ſprings*.

SECT. III.

But ſeeing that many recommend ſalts as promoting vegetation, ſome *brine*, others *nitre*, and not a few the *alkaline ſalts*; it is neceſſary that we inquire briefly into their reaſonings and experiments.

SECT. IV.

The efficacy of *ſea-ſalt* in promoting the vegetation of plants is taken chiefly from the following authorities:

1. That it is a common thing in *England* for people to enrich their land with *marine plants*, mixed with clay alſo obtained from the ſea, as CAMDEN relates of the county of Cornwall; whilſt others uſe *ſea-ſand*, as CHILDERY remarks in his *Nat. Hiſt.* which ſand is reckoned the better,

better, the deeper the water is where it is taken, as being in this case more stored with sea-salt. *Eph. Nat. Cur. Dec.* 1. *An.* 1692, p. 185, &c.

2. It is said that the *Gothlanders* make a manure of marine plants, such as *sponges* and other *sea-weeds*, which are laid in heaps that they may rot.

3. It is also alledged, that *sea-salt* has been successfully used for enriching of land: and hence Pott (*de Sale comm.* p. 31, &c.) contends, that the same *salt* mixed with *lime* and calcined, or mixed with *nitre* or *urine*, may promote the fertility of the earth.

4. Likewise, that *brine of sea-salt may prevent blight.* (*Eph. Nat. Cur. l. c.* Brookman, p. 144.).

Sect. V.

In answer to the above allegations (Sect. 4.) we answer,

1. That all *putrefied vegetables*, whether sea-plants or others, differ little or nothing from dung, and therefore answer the same purposes: but the good effects of putrefaction should not be imputed to any salt.

2. We have already declared (Chap. XII. Sect. 3.), that *sea-sand*, used properly, will conduce accidentally to the fertility of land. It has

also

alſo the advantage over ſand taken from land, that it retains it's moiſture longer, and free from the mixture of iron-ore frequently found in the latter: but it cannot be concluded from thence, that the ſea-ſalt contributes to the fertility of the ſoil.

3. As to the ſtreſs laid upon experiments, we anſwer, that by theſe we are rather convinced that ſalt renders land barren, than fruitful: for it is related in the *Eph. Nat. Cur. Dec.* 1. *An.* 2. p. 187, that ſeveral farmers who ſpread ſalt on their land in order to render it fruitful, were afterwards obliged to let it remain unſown for ſeven years. Indeed ſcripture informs us, that ſalt was formerly uſed in order to render land barren. Hence we may judge of chemical reaſoning which is not founded on experiments.

4. What relates to brine's preventing *blights*, muſt be left to future experiments; the diſeaſes of corn not being the ſubject of this work.

Sect. VI.

If, however, *ſea-ſalt* is applied in due quantity, it is not without it's uſes; for, uſed ſparingly, it attenuates and diſſolves the *oily particles* in the ſoil, and renders them miſcible with water. Thus it is that, when the ſea overflows the neighbouring

grounds, it is ſometimes attended with remarkable fertility, eſpecially when, with it's ſalt, it drops the *ſlime* contained in it. But here moſt authors have fallen into an error, by attributing to the ſalt only the fertility which ariſes from the *ſlime* or *richneſs* contained in the water, and from it's moiſtening the ſoil, as is experienced in the overflowings of the *Nile*.

Sect. VII.

The report in favour of *nitre* is ſtill greater. Mayow, in *Tr. de Nitro*, Glauber, Bacon, Digby, Lemery, Vallemont, Nieuwentut, and all who have copied them, or rather written of nitre, hold it forth as the *only* thing, as the very ſoul of vegetation and growth, and without which all ceaſes. The writers on huſbandry ſupport their opinion,

1. By the praiſe beſtowed on nitre by the *antients*.

2. By it's being of *celeſtial* origin, and preſent every where.

3. By it's being found in vegetables, on the burning of which it is turned to an *alkaline ſalt*, the nitrous acid being evaporated by heat: and

4. By it's fertilizing powers being confirmed by many experiments: for we find, that even dung is converted into a nitrous earth, and, being thus changed, exerts a ſurprizing power of fertility.

SECT. VIII.

Theſe arguments in behalf of the utility of nitre (Sect. 7.) will be found extremely weak and uncertain, if carefully examined; for,

1. It muſt be obſerved, that the nitre of the antients was the *natron*, or *mineral alkali*, as is well known to *mineralogiſts* and *chemiſts*, and very different from our nitre.

2. We will allow that *nitre is of celeſtial origin* in one reſpect, namely, it's *acid*; though *no real nitre has ever yet been found in the air*. The nitrous, muriatic, and vitriolic or ſulphureous acids are indeed ſcattered in our atmoſphere, and that in nearly equal quantity; but no one has hitherto been able to ſay, that theſe *ſalts* are to be met with in the air.

3. It cannot be denied, that there is in ſome plants an *eſſential ſalt* approaching to the nature of *nitre*; but ſuch plants are very rare, and in

those which are used for *food*, there is not any vestige of nitre, or of any other salt, as was before observed (Sect. 2. N° 3.) The alkaline salt produced by burning does not take it's rise from nitre, but from a new transposition, or composition, of acid, oily, and earthy particles, or from the essential salt.

4. We readily grant what is claimed from experience, that a nitrous soil is favourable to vegetation, and that dung may be changed into a nitrous earth by putrefaction: but what can be concluded from all this, other than that the richness in such a soil is rendered subservient to vegetation, by means of nitre? What therefore is principally owing to the richness of the soil, should not be imputed to nitre, which is only instrumentally useful.

SECT. IX.

Nitre has nearly the *same effect* on land that *sea-salt* has, namely (Sect. 6.), attenuating the oily rich particles, and thereby rendering them miscible with water.

Remark. It has been observed by some, that earth with which *nitre* is mixed *congeals*

sooner,

ſooner, and ſo breaks the roots of vegetables. See NIEUWENTUT. In this reſpect therefore nitre is hurtful, as well as by it's quality of hardening (Sect. 2:). The ſame is alſo the caſe of *common ſalt*, with which likewiſe an artificial cold may be produced. We read in *Memoir. de Mathem. et Phyſ. Tom.* I. *obſ.* 1. p. 3, *&c.* that fruitful ſoils have been rendered barren by nitre. C. DAHLMAN ESKILSSON has indeed attempted to demonſtrate that fertility does not any way depend on nitre: but it is to be lamented that his demonſtration is very imperfect, ſeeing he thinks that nitre is not to be conſidered as a *neutral* ſalt; but that acids and alkalies united, as well as other mineral ſalts, were created to promote fertility.

SECT. X.

Many commend the *fixed alkaline ſalt*, and *unwaſhed aſhes*. In ſupport of this,

1. They appeal to the experience of both the antients and the moderns, quoting VIRGIL, COLUMELLA, PLINY, and others; ſeeing it is proved that the *natron* of the antients was an *alkaline ſalt*.

It is ſaid, that the *Engliſh* enrich their ſoils by mixing with *ſand* burnt vegetables and their *aſhes*. Others manure their land with burnt *liver-wort**, or with the *aſhes* of burnt wood, &c.

2. They boaſt of the large crops which are obtained from land where a wood has been burnt down: and

3. They plead that an *alkaline ſalt* is to be found in every rich ſoil, agreeable to HIERNE's and KÜLBEL's experiments.

SECT. XI.

To obtain a diſtinct knowledge of the uſe of *alkaline ſalt*, we muſt inquire into it's nature, and from thence learn where it may be beneficial, and where hurtful, to land.

1. *Alkaline ſalts are uſeful,*

a. In attracting the moiſture and rich particles in the air, as alſo the acid, and in ſtrongly retaining them.

b. They diſſolve and attenuate the *oily rich* particles in the earth, whence ariſes a ſaponaceous ſubſtance ſoluble in water.

c. They correct the *acidity* in the ſoil, and retain the *moiſture* ſo that it cannot evaporate.

* A kind of moſs which grows upon damp rocks. The author undoubtedly means here all plants of that kind.

d. In

d. In ſo far as they prevent acidity, they help forward the fermentation which ariſes in the ſeed at germination.

e. They render tough ſoils looſer and more ſoluble, eſpecially if the unwaſhed aſhes are uſed. It muſt however be obſerved, that if they are applied in too great quantity, they may become hurtful, by exhauſting at once the rich oily matter, and by being of a burning hot quality: they therefore act in the ſame manner as *lime*, but are much ſtronger.

2. *Theſe ſalts become hurtful,*

a. By reſolving all the *oily rich* particles in the ſoil, whereby they render it barren for ſucceeding years, as appears, among other inſtances, in places where *woods* have been *burnt*; for after this has been repeated a ſecond or third time, trees will ſcarcely grow.

b. They *heat* ſoils too much.

c. They render the ſeeds of plants *harder*, as other ſalts do.

Hence it appears, that alkaline ſalts improve rich ſoils moſt, when uſed with prudence; and on the other hand, that they are more hurtful to barren ſoils, and indeed to every ſoil, when too

frequently or too freely used, than any of the other salts are.

SECT. XII.

From what has now been said it is evident, that all mineral and artificial salts contribute little or nothing towards the fruitfulness of the earth: but as there is not any plant or tree in which we may not find somewhat of a *saline* disposition, we may look upon that salt, *naturally acid*, to be produced and combined in plants, in the course of the fermentation, either from the *air* (Chap. V. Sect. 6.), or from *water*, together with the *inflammable matter* (Chap. I. Sect. 15. and Chap. III. Sect. 6.) Hence this *salt* differs, both in *taste* and in *quality*, in each plant and tree, according to the degree of fermentation and proportion of constituent parts (Chap. I. Sect. 6. and Chap. III. Sect. 6.)

Remark. Let us concisely mention here, *in what manner the constituent parts so different in plants can be produced from air and water.*

The *acid*, different in different plants (Chap. I. Sect. 6. and Chap. V. Sect. 6.), is produced by a certain *internal* fermentative motion, from the *acid* in the *air*, or in the *water*,

water, with a certain inflammable matter arising *from without*, communicated from the water or earth, or *from within*, by something in each seed, or from both these causes together. The *attenuated* or *spirituous oil*, which, by the difference in the smell, is found to be different in different plants, owing to a difference of the acid (Chap. I. Sect. 7.), is produced from the same principles, water, inflammable matter, and acid generated by the continued fermentative motion. From this attenuated oil, more and more concentrated by the acid, and united as by a farther concoction, is produced the *true* and *spirituous oil*, found existing apart, which therefore differs as the original *spirituous* particles differ. This is the natural and successive manner that Nature uses in producing the constitutive parts of vegetables, by slow degrees, from the simplest to the most compound. We before explained (Chap. III. Sect. 4.) in what manner the *farinaceous* part is generated from these substances.

That this theory of our's may not be thought merely ſpeculative, we appeal to chemical experiments, related by many: we likewiſe appeal to rain-water, dews, and other ſtagnating waters, or lakes covered in ſummer with an efflorescence, from all which, even the pureſt of them, the principles which we have ſpoken of may be obtained, when expoſed to the heat of the ſun.

We therefore conclude, that *no mineral or artificial ſalts, nor any mineral earths, contribute to the nouriſhment of plants.*

CHAP.

CHAP. XIV.

OF PROMOTING THE MULTIPLICATIVE POWER OF SEEDS BY ART.

SECT. I.

HITHERTO we have ſaid what *nature* can do towards promoting vegetation: we are now to conſider wherein *art* can contribute thereto. Order conſequently requires that we begin with the *ſeeds* (Chap. II. Sect. 5. N° 3.), to proceed afterwards to the *ſoils*.

SECT. II.

With regard to *the multiplicative power of ſeeds*, of which we have treated fully in Chap. III. the writers upon agriculture have eſpouſed *three opinions* concerning the means *of promoting it by art*. Some have thought, that ſeeds may be rendered more prolific by planting them in a *nurſery* prepared for that purpoſe (CHR. WOLFIUS, *de mirab. multip. Sem.* STRIDSBERG, in his Swediſh Treatiſe,

Grund. Kunſk. om Sv. Akerbrau); others, by ſteeping them in ſome liquor, which is the prevailing notion of farmers; and laſtly others, by *fumigation*, or by ſprinkling them with certain powders.

SECT. III.

They who endeavour to promote the fertility of ſeeds *by planting them in nurſeries*, of which it ſeems to us needleſs to give here a long deſcription, pretend to juſtify their method by experience and analogy, from which it appears, that a due degree of richneſs and of moiſture in the earth ſtrengthens the multiplicative power of the ſeeds, as we have demonſtrated in Chap. III. Sect. 8. N° 3. (See alſo WOLFIUS, *de vi Semin. multipl.* Chap. III. Sect. 14.) For this reaſon it is that ſeeds obtained from ground which has been *burn-baked* are generally moſt prolific. They therefore judge it uſeful and neceſſary to eſtabliſh nurſeries, in which all due care may be taken of the things planted, in order to obtain from them plump heavy ſeeds, indued with the power of germinating eaſily.

SECT.

Sect. IV.

To give our opinion of *the plantations here ſpoken of*, we think it beyond all doubt that the plentifulneſs of the crop depends in a great meaſure on the ſtrength and goodneſs of the ſeeds (Chap. III.): but plants do not derive their life and growth ſolely from the nouriſhment that is in the ſeed; for they ſtand likewiſe in need of that which the air and the ſoil may furniſh them with. Many other extrinſic circumſtances, which we have pointed out in Chap. III. Sect. 8. alſo contribute to the goodneſs of ſeeds: and beſides them, equality in the height of the plant does not depend on the ſeed itſelf, but on the due formation of *the joints of the ſtem*, which proceeds from the nature and richneſs of the ſoil, according to WOLFIUS's obſervations in the place before quoted; in the ſame manner as a chicken, after it is hatched, no longer takes it's nouriſhment from the mother, but from the food given to it, or which it procures itſelf. It is eaſy to ſee from thence, that it is not yet determined whether the goodneſs of the ſeeds ought to be preferred to the goodneſs of the land. If both of them meet together, the crop will be

by

by ſo much the more plentiful; but otherwiſe, we think that a huſbandman ſhould above all take care that his lands be well cultivated and ſufficiently enriched.

Hence it follows, that whoever would eſtabliſh a nurſery of this kind, ſhould begin with calculating,

1. Whether the quantity of richneſs in the land is ſufficient for the ſoil and for the nurſery?

2. Whether the utility accruing from the plantation and the nurſery, will compenſate for the labours and expences they occaſion?

We, who are perſuaded that the ſeeds of vegetables may eaſily be damaged by cold, by age, by the climate, and perhaps alſo by other accidental circumſtances, believe that ſeeds are not ſo much improved by theſe nurſeries, which require a great deal of time and labour, as to render them worth while; but that the principal object of the huſbandman ſhould be, the amending and enriching of his land: in the mean time, however, it is abſolutely neceſſary to chooſe for ſowing, ſuch ſeeds as we have pointed out in Chap. III. Sect. 8. and always to prefer the beſt.

Remark.

Remark. We may farther add to the above-mentioned difficulties which attend theſe nurſeries, that we ſhall frequently find ſeeds of a ſmaller ſize ſprout ſooner than thoſe which are larger; juſt as one often ſees robuſt parents bring into the world weak and infirm children. As to the reſt, it is alſo to be obſerved, that, in too rich a ſoil, the nutritive power of vegetables is increaſed, rather than the multiplicative: whence the leaves become larger, and the ſtem thicker, but the ſeeds ſmaller, or leſs ripe.

SECT. V.

They who have recourſe to *ſteeps to fertilize ſeeds*, ſeem to propoſe to themſelves two different ends.

1. *Some* intend thereby to preſerve their ſeeds from *worms* and *diſeaſes*; and for this reaſon it was that the antients called theſe ſteeps *medicinal*.

2. *Others*, to increaſe the multiplicative power of the ſeeds, which, according to ſome, may be effected by *ſoftening of the membranes and exterior coverings*; whilſt others think that the ſeeds acquire this power by immerſion in certain ingre-

ingredients, to such a degree that the vegetables which proceed from them can afterwards grow perfectly well to maturity.

From hence arise the three following questions;

1. *Can seeds, by the use of any mixture, be so far medicated, or strengthened, as to be guarded from diseases, worms, and other accidents?*

2. *Is it of any service to soften the skin or covering of the seeds before they are put into the ground?*

3. *Is it possible to communicate to the seeds a power capable of making them grow to maturity?*

SECT. VI.

PLINY, B. XVIII. C. 17, gives us plainly to understand, that the antients made use of medicinal applications, in order to preserve their plants from diseases, worms, and even birds. This was also the intent of the preservatives mentioned by VIRGIL and DEMOCRITUS. Many of the *moderns* usually compose these preservatives of *lime*, or *soot*, or the *juice of garlic*, or some other similar matter.

We wish that a *panacæa* of this kind was found out, capable of guarding plants from distempers and worms.

With

With regard to the *diſtempers* of the *ſeeds* of vegetables, we are of opinion that they cannot be attacked by any other than thoſe which proceed from a defect in their *juices*, occaſioned either by *old age*, or by ſome *bad quality imbibed from the ſoil, or air*. If they are the effect of *age*, there is no remedy; but if they ariſe from the *ſoil*, the cure muſt be applied *to the ſoil*, and *not* to the ſeed.

Remark. The queſtion here is not properly concerning *the diſtempers of ſeeds*, but rather *the diſtempers of the plants which proceed from thoſe ſeeds*. In the *former caſe*, if the ſeeds are corrupted and ſpoiled, the evil is eaſily remedied, by ſubſtituting in their ſtead others which are ſound and prolific. In the *latter caſe*, the diſtempers of the plants depend leſs on the ſeeds, than on the ſoil, or on the influences of the air. For this reaſon it is, that it may perhaps be poſſible to prevent *blight* and *ſmut* by the uſe of *lime* or of *marle*. See Chap. XI.

Worms and *inſects* attack either the *ſeeds* themſelves, or the *plant* produced from the ſeed. Now it

it is evident that worms do not derive their *origin* from the ſeeds, as is likewiſe proved by KRAFTIUS's experiments in *Nov. Comm. Ac. Petrop. Tom.* II. for he obſerved in *kidney-beans*, on the fourth day after having planted them, long hairy worms gnawing the leaves of the germ ſcarcely yet protruded; though MUSSCHENBROEK, in his *Diſcourſe on the* WISDOM OF GOD, is of a different opinion. He afterwards planted ſome of thoſe kidney-beans, and others, in well dried earth, and after having moiſtened them with diſtilled water, could not perceive any worms about them. *Therefore the origin of thoſe worms*, which prey upon the ſeeds of vegetables, *is to be ſought for in the nature of the ſoils which afford them a convenient and viſcous abode*, ſuited to their nature. We have likewiſe ſtrong reaſons to doubt, whether the worms hidden in the earth can attack *ſeeds*, unleſs there be previouſly in them ſome *principle of corruption*. CHR. WOLFIUS has from thence juſtly concluded, in his letter to KRAFTIUS, that the worms which are found in ſeeds are a conſequence of the *old age of the ſeeds*, or of ſome *vitiated juices generated in them*, owing to the inclemency of the ſeaſon, or to ſome other cauſe; as we ſee that *worms* cannot live but in weak children, whoſe bowels are full of ſlime.

Worms

Worms therefore cannot live but in vitiated ſoil, and can ſcarcely attack any ſeeds but as ſuch are already damaged. The beſt remedy againſt them therefore is, *to correct the defects of the ſoil, and always to chooſe ſound ſeeds for ſowing.*

We do not, however, mean by this, to condemn as uſeleſs all preſervatives againſt worms: on the contrary, we believe them abſolutely neceſſary, eſpecially when one cannot rightly know and correct the defects of the ſoil, or diſcover the inconvenience ariſing from the air, or other cauſe. But we leave to experience to determine whether this remedy is to be ſought for in ſteeps, or in fumigation, or by ſome other method.

Remark. It has lately been experienced, that the ſmell of *gun-powder* preſerves *turnip* ſeeds from worms. To this end, they need only be mixed with ſome of that powder, and ſtirred about a little with it. Others adviſe, as a preſervative againſt worms, to ſprinkle the ſeeds with *juice of garlic*; and indeed, as almoſt all worms fly from this ſmell, the remedy would be good, if it laſted longer than it does. Others recommend *hemp* to keep

keep off *butterflies*, or to lay upon the land *turf dug out of marshes*, or the *dung of poultry*. In fine, there are who recommend againſt *worms*, and againſt the *fly*, which gnaw *plants* in the ſummer, ſome *ſoot*, others *lime*, and ſo on. But theſe remedies muſt be uſed with great caution; for we have ſeen that the *lime* which gardners ſprinkle upon the moſt tender plants, has ſometimes totally deſtroyed them.

Sect. VII.

Let us now proceed to the ſecond queſtion which we propoſed in Sect. 5.

Is it of any ſervice to ſoften the ſkin or covering of the ſeeds before they are put into the ground?

It is not to be doubted but that the radicule and the germ can more eaſily open themſelves a paſſage through the coats of the ſeed when they are tender, than when they are harder, and that the nutritive juices can enter more eaſily into the ſeed when it's covering is ſoftened and it's pores are more open. Conſequently, it is ſufficiently evident, that, in this reſpect, the practice of ſoftening the coats of the ſeeds is not to be deſpiſed.

But

But this does not yet determine the queſtion; for it is neceſſary at the ſame time to conſider, *whether there may not reſult from this method more and greater inconveniencies, which it may be difficult to prevent.* Now it is evident, that the viciſſitudes of the ſeaſons may eaſily corrupt and entirely deſtroy the ſeeds ſo ſoftened; for

1. If *too great a heat* comes on ſoon after theſe ſeeds have been put into the ground, all the watery particles, as well of the ſeeds as of the earth, are exhaled: by this circumſtance theſe ſeeds loſe more than they can gain; and they muſt neceſſarily become dry, ſhrivelled, and at laſt die.

2. When *cold* enſues, the water contained in the ſeeds freezes, and burſts their veſſels.

3. When the air is *too damp*, the veſſels become diſtended, and corrupt through a too great humidity.

It is likewiſe farther to be obſerved, that water poured copiouſly upon ſeeds, may as well *take from their vigour*, as add to their ſtrength, unleſs this moiſtening be executed with great circumſpection. For if the ſeeds are left in the water long enough for them to ſwell, that water muſt neceſſarily extract

tract conſiderably from them, as appears by it's *taſte* and *colour*.

It ſeems to us highly ridiculous to conceit, as ſome have done, *that the fertility of ſeeds intended for ſowing can be increaſed by ſteeping them in water in which ſeeds of the ſame kind have been boiled*; as if the water drew their virtue from theſe laſt, and could by a contrary operation communicate it to the former.

Upon the whole then we conclude, that *the ſoftening of ſeeds, managed with prudence, is uſeful in ſome reſpects; but, at the ſame time, that it is very dangerous.*

Remark. We grant that there have been made upon the ſoftening of ſeeds a great number of experiments, which have ſucceeded well: but that ſucceſs is to be imputed, *either to the ſeaſon, favourable* in that the ſeeds were not dried up by too much heat, nor deſtroyed by cold, nor rotted by wet; *or to the goodneſs of the ſoil*, which was rich enough to afford them ſufficient nouriſhment; *or to the ſkill of the huſbandman*, or *gardener*, who knew how to prevent a too great drought, by watering.

SECT.

SECT. VIII.

Many have thought it poſſible *to communicate to ſeeds, by art, a vegetative power which ſhould make them grow without ceaſing, to their full maturity* (Sect. 5. N° 3.) CARDAN, *de Subtil. Lib.* XIII. p. 513, tells us, that this may be done by anointing the ſeeds with *oil*; which ſeems to be confirmed in the *Journal des Sçavans* for the year 1684, p. 53. We likewiſe read in the ſame Journal for the year 1685, p. 14, that EDM. WILDE had made *lettuce ſeeds* ſprout within the ſpace of two hours after putting them into an earth he had prepared for that purpoſe. REGNAULT too ſays, in his *Extrait de Phyſ. Tom.* III. p. 62, that the ſame thing may be effected by ſteeping the *lettuce-ſeeds* in *brandy*, and afterwards mixing them with *lime and pigeon's dung*.

But the following reaſons authorize us to doubt theſe experiments.

1ſt. We are perſuaded that this kind of power of growth can no more be communicated to ſeeds, than the *embrio* of a plant can, contrary to all experience, attain to maturity by the uſe of that food which it received in the *ſtamen*.

2dly. It

2*dly*. It is repugnant to the repeated experiments of LORD BACON, who, in his *Nat. Hiſt. Cent.* V. tell us, that *ſeeds ſteeped in malmſey wine*, and *in ſpirit of wine, did not grow at all.* So likewiſe ſays KRAFTIUS, in *Nov. Comm. Ac. Petropol. Tom.* II. who alſo found, that neither *ſpirit of wine*, *milk*, nor *urine*, make ſeeds grow. He even arraigns the want of judgment of ANT. LE GRAND, of BACON, and of the anonymous author of the book intitled *Entdeckte Gruft naturl. Geheimn.* (i. e. *Diſcovery of the Secrets of Nature*), who thought that plants of an acrid nature might be rendered ſweet by ſteeping their ſeeds in honey. Dr. HALES too has remarked the falſity of this opinion, in his *Vegetable Statics*. In fine, the communication of this vegetative power is contrary to the experiments of M. BONET, who, in his *Inquiries concerning the Uſe of the Leaves*, teſtifies his having obſerved that the leaves of vegetables were *ſhrivelled up* by making them imbibe vinous and ſpirituous liquors. We will farther add to all theſe experiments, thoſe which we ourſelves have made, by which we are convinced that *ſeeds ſteeped in oil* contract thereby rather an additional *hardneſs*, and thereby can no longer germinate.

3*dly*. It

3dly. It is ſufficiently evident from what has now been ſaid, that vegetables draw their nouriſhment ſolely from water and rich particles reſolved into vapours; and that they very difficultly retain any portion of *more tenacious* or *more ſpirituous* ſubſtances.

SECT. IX.

The means of procuring *fertility to ſeeds by immerſion* are either *ſimple*, conſiſting of only one ſubſtance, or *compound*, containing a mixture of ſeveral ingredients. There are *ſix kinds of the former*, namely, the *watery*, the *alkaline*, the *nitrous*, the *oily*, the *arinous*, and the *acetous* or *vinous*: the *latter* are of *three kinds*, viz. the *ſaponaceous*, thoſe which are compoſed of *a mixture of rich and nitrous particles*, and laſtly thoſe which conſiſt of *oil* and a *ſpirituous ſubſtance*.

SECT. X.

With regard to the immerſion in *water*, which *gardeners* generally practiſe, we think it preferable to every artificial immerſion, eſpecially if one uſes for that end *rain-water*, which furniſhes an excellent nouriſhment to vegetables, and is mixed

with the fine ſaline and oily particles of the air (ſee Chap. V. Sect. 8, 10.), and which beſides does not impede the natural fermentation. But it is likewiſe neceſſary to remember the *inconveniencies* which may reſult from this immerſion (Sect 7.)

Sect. XI.

We compriſe under the *alkaline ſteeps* which give fertility, thoſe that are made of a *ley* of *aſhes*, of *alkaline ſalt*, or of *lime*. But what has been ſaid of *lime* (Chap. XI.), and of the *alkaline ſalt* (Chap. XIII. Sect. 11.), gives us ſufficiently to underſtand what ſhould be thought of theſe ſteeps. We will only add, that the ſame advantages can ſcarcely be expected from ſteeping the ſeeds in a ley of alkaline ſalts or lime, as we have ſaid may be reaped from a mixture of theſe with earth or dung; ſince experience teaches us, that though theſe ſalts and lime penetrate but little into the ſeeds, they nevertheleſs cauſe ruptures in them, and rather tear than fertilize them; and that by adhering to the outſide of the ſeeds, they render them harder than before.

Sect.

SECT. XII.

The rendering of ſeeds fertile by means of a *nitrous ley*, is very highly extolled by DIGBY, in his *Treatiſe on Vegetation*; by HOMBERG, in the *Memoirs of the Royal Academy of Sciences for the year* 1699; by NIEUWENTYT, in *Welt-Bet*; by WOLFIUS, in his *Tr. de mult. ſeminum*, and by others: But after having made experiments on ſeeds ſteeped in a ley of nitre, and ſown in barren land, we have learnt that this trial is *fallacious*. The ſeeds ſteeped in this ley are rendered *harder*, and are ſooner *ſpoiled by the cold* (Chap. XIII. Sect. 8, 9.); and this ley is fitter to diſturb, than to favour, the interior motion which takes place in ſeeds during their germination.

SECT. XIII.

Many think that *urine* has the power of greatly fertilizing ſeeds: ſee BROOKMAN's *Huſhälſt.* p. 151. STRIDSBERG, in the book before quoted, p. 66, who ſuppoſe that there is in urine a *vegetable* and *penetrating ſalt*, though the chemiſts have not been able to diſcover in it any other than a certain *ſemi-volatile ſalt*, approaching nearly

to the nature of *ſal ammoniac*. We do not deny that *urine* contributes very greatly to the fertilizing of land, by reaſon of it's *oily*, or rather, in ſome ſort, *ſaponaceous*, *though acrid quality*; for urine mixes perfectly well with *water*, and experience teaches us ſufficiently the good effect which it produces when mixed with either *earth* or *dung*: but that *urine alone*, *and by itſelf*, can promote vegetation, either by ſteeping the ſeeds in it, or by ſprinkling it upon the ground, is repugnant to KRAFTIUS's *experiments*, and to all *obſervations*, which prove that urine renders vegetables pale, and almoſt deſtroys them. Seeds may indeed be ſoftened by urine; but, at the ſame time, the *ſharpneſs* which is peculiar to it cannot but corrode their coats and ſmall veſſels, and diſturb their fermentative motion.

Urine ſhould therefore not be uſed alone, neither upon land, nor for ſteeping of ſeed; but it ſhould be well mixed with dung, in order to blunt it's acrimony, and give it a ſaponaceous nitrous quality when incorporated with the oily particles in the dung.

Remark. We ſhall examine in the chapter concerning *manures* (viz. Chap. XV.) whether *putrid urine* is preferable to *freſh*.

SECT.

SECT. XIV.

It is now leſs cuſtomary to ſteep ſeeds in *oil*, in order to increaſe their fertility; nor do we indeed know whether that was preciſely the end which the antients propoſed to themſelves in making uſe of the *lees of oil*. However that may be, it is certain that the *oily particles* ſtop the pores of vegetables, prevent water from entering them, and thereby hinder their receiving almoſt any nouriſhment (Sect. 8.)

SECT. XV.

Some commend *an acid*, as well in the ſoil, as in the ſteeps: but all the modern cultivators are with reaſon of a quite contrary opinion, becauſe they know that acids diſturb all fermentation, and that far from helping the ſeeds to germinate, they are rather a hindrance to them, which is likewiſe proved by *preſerves* made with acid fruits.

SECT. XVI.

Many have advanced, that it had been long obſerved, that *wine agreed with plants*, and that they were ſeen to *revive when ſprinkled with that liquor*, (ſee BROOKMAN, p. 146, of his above-

quoted work.) But LORD BACON, KRAFTIUS, and BONET, have ſhewn by their experiments the error of that opinion (Sect. 8.)

SECT. XVII.

We comprehend under the name of *ſaponaceous* ſteeps, thoſe which are made with *alkaline ſalt*, *lime*, or the *ley of aſhes*, mixed with the *draining of dung*, or with *urine*, adding likewiſe thereto ſometimes other ſalts, as *ſea-ſalt*, or *nitre*. (See BROOKMAN.) In theſe mixtures, the oily are combined with the watery particles, by means of the lime, or of the ſalts, and thereby form a ſalutary food for plants. But we muſt obſerve,

1*ſt*. That the ſeeds ſo ſteeped run the ſame hazards as may reſult from any ſteep in general (Sect. 7.)

2*dly*. That theſe ſeeds cannot but loſe of their fertility, when the ſun and the temperature of the air are favourable to vegetation: for when they are ſown in a rich earth after having been ſteeped, they put forth the ſtronger roots, and larger and thicker leaves, which conſequently draw, as well from the air as from the earth, a greater quantity of nouriſhment, whereby the veſſels of the plants

are

are extended too much, and the ſtem is made to incline. It likewiſe happens from thence, that, through the abundance of moiſture, the ſeeds become more watery than farinaceous, and that they ſhrivel up and flatten when that water is evaporated.

3*dly*. It is evident from the afore-mentioned experiments (Chap. VI. Sect. 3. N° 4.) that only very ſlender advantages can be hoped for from theſe ſteepings of ſeeds.

SECT. XVIII.

Under the *oily and nitrous* ſteeps we comprehend, thoſe which are made with an *oily ſubſtance* and *nitre*. Such is the mixture commended by JOHN JOACH. BECKER, in his book intitled *The prudent Huſbandman*, (*Kluger Hauſvater*), and which has been ſince repeated by SALANDRE, in his *Gärdſfogdte Inſtr*. p. 150. We likewiſe find it recommended in the *Diſcovery of the Secrets of Nature* (*Entdeckter Gruft aller Geheimniſſen*), and which is for the moſt part approved of by STRIDSBERG, in his *Swediſh Agriculture* (*Svenſka äkerbr*.): not to ſpeak of ſeveral rules which have been left us thereupon by VALLEMONT, in the place above-

quoted; CHRIST. TRAUTMAN, in the *Zittau Kalendar (Zittauiſche Calendar) for the year* 1720; KUNHOLD, in his *Oeconomical Experiments*; JOHN WALLENBERG, in his *Collection of Writers on the Works of Nature (Saml. Naturl. Zauberbüchern)*; BROOKMAN, in his *Huſh. Bok*, and others, who all agree in mixing ſome *rich draining of a dung-hill*, or ſomewhat of that kind, with a *ley of nitre*. But we obſerve in regard to this kind of ley, that the whole artifice *reſts upon a falſe hypotheſis*, namely, that nitre is a vegetable ſalt (See Chap. XIII. Sect. 8.); and that ſo great a quantity of nitre is badly employed, ſince no advantage can be derived from it, but rather hurt (Sect. 10.) It is ſometimes remarked that vegetables grow uncommonly well after their ſeeds have been ſteeped in theſe mixtures: this effect ſhould be imputed to the union of the oily and watery principle, rather than to the nitre. As to the reſt, the nitre excepted, theſe mixtures are near a-kin to thoſe which are compoſed of *alkaline ſalt and oil* (Sect. 17.)

SECT. XIX.

With regard to *compound ſpirituous* ſteeps, they are of different kinds. Some have endeavoured to extract

extract the eſſence of *dung* with wine, or *ſpirit of wine* (See WALLENBERG, in the place above-quoted); others have tried to ſeparate a ſomewhat from *nitre* (ſee JOHN GOTSCH. TRANÆUS's *Diſp. de Calce viva*, p. 26.) others, from the ſeeds of *vegetables*, and imparting their extract to other *ſeeds*. But as we before obſerved (Sect. 8, 16.), *ſpiritous liquors* deſtroy vegetables, rather than ſerve them for food: beſides, it is known that thoſe ſpirituous ſubſtances, being of a volatile nature, cannot adhere long to the ſeeds, but ſoon evaporate. It is evident then, that it is a miſapplication of wine, and of ſpirit of wine, to endeavour to make them anſwer a purpoſe in which they are even hurtful.

SECT. XX.

From what has now been ſaid, it plainly appears, that *no ſteep for ſeeds is abſolutely ſafe*, but that each has it's particular dangers (Sect. 7.) But if, notwithſtanding this, any are ſtill determined to recur to ſteeps, we cannot too much exhort them to prefer, and to uſe with moderation, thoſe which are compoſed of *ſimple rain or ſoft water* (Sect. 10.), or of *ſaponaceous* or *oily and alkaline* mixtures (Sect. 17.)

SECT. XXI.

We are now to inquire, wherein *lime* and *soot* applied *dry*, and mixed with the ſeeds which are to be ſown, and alſo the *fumigating of ſeeds*, can contribute to the advancement of vegetation.

SECT. XXII.

It is eaſy to infer from what we have ſaid in Sect. 11. and Chap. X. what ſhould be thought of mixing dry *lime* with ſeeds: we will only add here, that dry lime will ſcarcely adhere to dry ſeeds, and that it conſequently produces then a much leſs conſiderable effect, than when it is mixed with the ſoil.

SECT. XXIII.

Soot, according to chemical analyſis, is compoſed of *oily*, *ſaline*, *watery*, and *earthy* particles, which may be ſeparated by infuſion and diſtillation. *Common water* diſſolves about a fourth part of ſoot, which is *gummous*, and compoſed of oil, water, earth, and ſalt (Chap. I. Sect. 9.) One may therefore extract from ſoot, by the means of water, parts homogeneous to thoſe of vegetables (Chap. II.

Sect.

Sect. 6.) But it has a certain bitterneſs, produced by an alkaline ſalt combined with the oily parts, and which proves it to be of a *ſaponaceous* nature, whereby it reſolves the thick and viſcid juices in ſeeds. It is alſo for this reaſon that it is an *enemy to worms*. Beſides, on account of the oily or inflammable parts which it contains in great abundance, *it reſiſts cold for a long time*, and receives from the air a greater degree of heat. Soot has alſo the power of *retaining long the watery parts and moiſture*, nearly like the aſhes of coals moiſtened.

Soot contributes then to the advancement of vegetation,

1*ſt*. *Materially*, by ſupplying the place of the beſt dung, for the nouriſhment of plants.

2*dly*. *Inſtrumentally*, and that 1, by receiving and retaining *heat*; 2, by retaining long *rain-water*; 3, by *reſolving the glutinous parts* of ſeeds; 4, by *preſerving them from the injuries occaſioned by worms*; 5, by deſtroying, by means of its alkaline ſalt, the acid as well in the earth as in the ſeeds.

Soot, when uſed in too great quantity, *hurts alſo by its acrimony*, which is capable of ſtopping

or even deſtroying all fermentation in the ſeeds, and even of corroding vegetables.

Every one will eaſily perceive from what has now been ſaid, that *ſoot uſed with moderation* may be of very great ſervice, if it is *mixed*, but in a leſs quantity, *with the earth*, in lieu of dung; and that, on the other hand, it cannot produce the ſame effects by mixing it only with the ſeeds, becauſe dry ſoot adheres but ſlightly, it is eaſily diſſipated, and that, beſides, it's principal utility is derived from it's extract, or from the watery tincture which nature prepares in the earth.

Remark. The Engliſh ſet great ſtore upon ſoot, though the ſoot of *ſea-coal*, or *pit-coal*, cannot produce the ſame effects as that of *wood*. (See *Allgem. Haußhalt and Landtviſſ.* p. 313. i. e. *Univ. Oecon. & Agricult.*) There is even a great difference between *the ſoot of different woods*, which ought to be conſidered. Alſo, the ſoot of kitchen chimnies is more *oily*, and that of other chimnies more *alkaline*: the former ſhould be applied to ſandy ground, the latter to low clayey land. The Engliſh eſteem a quarter of a ton of ſoot equal to a whole load of dung.

SECT.

SECT. XXIV.

Soot proceeds from ſmoke, as experience ſhews; therefore there cannot be any great difference between them. For this reaſon, ſome have recommended, inſtead of ſoot, *to expoſe the ſeed to ſmoke*, in order to promote vegetation; and it is not to be doubted that ſmoke penetrates the coats of the ſeeds, as may be concluded from both the brown colour and the bitter taſte of beer made of malt, which has contracted that taſte and colour by being dried over a kiln.

The effects which we have aſcribed to ſoot (Sect. 23.), authorize us to believe that *fumigation* prevents that *too great acidity of the ſeeds* which hurts their fermentation, and that it prevents the effects of external *cold*, and drives away *worms*: but if we conſider at the ſame time, that the fumigation cannot be inſtituted any other way than that the heat, which accompanies the ſmoke, ſhall diſperſe the *watery* and *volatile* parts of the ſeeds, nor without it's communicating to the ſmoke itſelf a certain *acrimony*; we ſhall eaſily conceive that fumigation retards more or leſs the fermentation, or germination of the ſeeds, in proportion to their being

being more or leſs dry, as is the caſe in *old* ſeeds (Chap. III. Sect. 9 N° 5.), or by communicating too great a degree of acrimony, totally deſtroys all germination.

We conclude then, that if recourſe is had to the *fumigating of ſeeds*, that fumigation ought to be very gentle, and the ſmoke as cold as poſſible: but firſt it ſhould be weighed, whether the utility accruing from fumigation can compenſate for the trouble and expence.

CHAP.

CHAP. XV.

OF MANURING OF LAND.

SECT. I.

THE *manuring of land* is that operation by which is communicated to it the ſubſtances from which vegetables can draw a ſufficient nouriſhment.

Remark. ZINCK, in his *Lex. Oecon.* gives us a very ample account of manuring, which we do not think neceſſary to inſert here. We content ourſelves with only obſerving, that he does not at all agree with the theoretical principles of chemiſtry, when he ſays, that *the oily particles added to the ſoil excite a kind of fermentation with the oily particles previouſly in the earth, and with the moiſture of the air, and that from thence are produced ſaline, oily, urinous, empyreumatic, inflammable, alkaline, &c. particles, which open the ſeeds of plants, and enable them to grow.* Every one in the leaſt converſant with chemiſtry will readily perceive the futility of this reaſoning.

SECT.

Sect. II.

It appears evidently from former demonſtrations, that vegetables ſtand in need of a certain homogeneous matter, to make them grow (Chap. II. Sect. 6.): but if neither the *ſoil* (Chap. VII.), nor the *ſalts*, can be conſidered in themſelves as principles for the nouriſhment of plants (Chap. XIII.); there can be no other analogous ſubſtances in the earth, from which vegetables draw their food, than the *oily* and the *watery* particles, as we have ſhewn in Chap. VII. Sect. 4. From hence it follows, that *the manuring of land conſiſts chiefly in communicating to it a ſufficient quantity of oily and watery particles.*

Remark. Having before given (Chap. IV. and V.) an account of the nutritive matter furniſhed by the *air*, we here ſpeak only of ſuch *matter in the ſoil*, as vegetables derive their growth from.

Sect. III.

The ſubſtances in which there is a mixture of *oily and watery* particles, conſtitute the beſt manure (Sect. 2.): but as oil and water, in a fluid

fluid ſtate, and in too great quantity, do more hurt than good to plants (Chap. VI. Sect. 11, 12. Chap. XIV. Sect. 14.), and as they cannot penetrate the pores of vegetables, unleſs they are *ſubtilized and reſolved into vapours* (Chap. II. Sect. 4.); the beſt matters for manure are, thoſe which afford attenuated oils, and a water reſolved into vapours. Now it is obſerved, that oil is attenuated, and water reſolved into vapours, in thoſe ſubſtances whoſe interior parts are ſubject to motion, or liable to putrefaction: from whence we conclude, that *matters of this kind, ſubject to ſuch internal motions, conſtitute the beſt nouriſhment of vegetables.*

Sect. IV.

It is well known, that there are *five kinds* of oily particles, namely, the *aërial*, the *mineral*, the *vegetable*, the *animal*, and *a mixture of theſe*. But as the oily particles of the *mineral* kingdom have no affinity with thoſe of vegetables, as appears from an analyſis of them in Chap. I. and as we have already treated ſeparately of the *aërial*, in Chap. V. we ſhall here ſpeak only of the *vegetable* and *animal* oils, and their *mixtures*.

Sect.

Sect. V.

Theſe preliminaries, together with what we have ſaid in Chap. II. concerning the principles of vegetation, authorize us to draw the following concluſions.

1. *The nearer the matter intended for manure approaches to the nature of vegetable oil, the better it is.* Therefore, all other things being equal, vegetable manure ſhould be preferred to that which is mixed, and this laſt to animal manure alone.

2. *The ſooner the oily particles contained in the matter which is to ſerve for manure are conſumed, the leſs can they be profitable to the huſbandman.* But as it appears from experience, that the vegetable manures are leſs durable than the mixed, and that the animal is leſs durable than the vegetable, the mixed ſhould on this account be preferred.

3. *The more oily particles there are in matter, the richer and more durable it muſt neceſſarily be.* It is for this reaſon that mixed manure ſhould be preferred to others, and that the *dung of well-fed cattle* is infinitely better than that of lean ones, as C. G. Boye has obſerved in his book intitled *Förfarna Sv. Landth.* p. 54.

4. *The*

4. *The more the matter which is to ſerve for manure is diſpoſed to putrefaction, the more eaſily it is ſubtilized, and reſolved into vapours* (Sect. 3.) On this principle, the *animal manure* ſhould be preferred to that which is compoſed of the animal and vegetable, and this laſt to the vegetable manure alone; and hence alſo, dung mixed with *urine* is by far preferable to dung not mixed with urine, independent of the conſideration that it acquires by this mixture a greater quantity of oily particles. (See Chap. XIV. Sect. 13. and alſo C. G. Boye, l. c. p. 185.)

Remark. The *dead bodies of animals* ſhould by no means be buried in arable land, on account of very many evils which might ariſe therefrom. But they conſult perfectly well the intereſt of their land, who leave their cattle upon it during the night, incloſed in fields, in order that they may fertilize it by their dung, urine, and perſpirable matter; and this method will be ſtill more advantageouſly practiſed, if the land is firſt covered with a layer of ſtraw, to prevent in ſome meaſure the evaporation of theſe manures, and if all theſe matters are afterwards plowed in.

Sect.

Sect. VI.

Dung is a vegetable ſubſtance ground ſmall, as is proved by remains of vegetables found in it, *mixed with the ſaliva, the juices of the ſtomach and inteſtines, and the bilious matter, of animals.* Dung is therefore a *mixed* body, readily putrefying, containing an unctuous matter, very nearly approaching to the nature of vegetable oils. It communicates a laſting manure, which is obtained with little trouble, and very cheap. It is therefore beyond all doubt, that dung ſhould be ranked among the beſt manures.

Remark I. They ſeem to be miſtaken, who aſcribe the richneſs given to land by dung, to a certain *ſaline* ſubſtance, more or leſs inherent in the dung, as C. Dahlman Eskillson teaches, in his *Huſb. Rön.* p. 100: for if we examine attentively the very experiments which *that author* made with leys of different ſorts of dung, and with *acid ſpirits, alkaline ſalts, &c.* it will appear, that, far from finding in them *alkaline ſalt, ſulphur*, and *nitre*, in abundance, as he thought, he diſcovered in them only a very

very little *volatile alkaline ſalt*, depending on the putrefaction more or leſs prolonged, and an *oily principle* united with the *water* by means of that ſalt. Conſequently, all the difference in dung depends ſolely on the quantity of it's *unctuous particles*, and their *ſolubility in water*. The quantity of the unctuous principle may be known by diſtillation, and it varies according to the quality of the animals (Sect. 5. N° 3.) The more the dung is unctuous, the *warmer* it is. Hence the dung of fowls, which feed on ſcarcely any thing but ſeeds, is hotter than that of *horſes*, the dung of horſes hotter than that of *cows*, and ſo of others.

Remark II. M. DUHAMEL DU MONCEAU, in his *Traité de la Culture des Terres* *, having adopted the falſe principles of an Engliſh writer, JETHRO TULL, on the utility of dung, could not but draw from thence wrong concluſions: but as his theory has

* The ſubſtance of that juſtly celebrated work is contained in MILLS's *Treatiſe of Huſbandry*, Quarto.

been

been propagated in other writings, and particularly in the book intitled *Allgem. Haußhalt. und. Landtwiſſencſh.* p. 238, &c. *Univ. Oeconom. & Agricult.* we will here give it a brief examination.

1*ſt.* He ſays, that *dung operates in the ground only by dividing, as well by its putrefaction as by it's interior motion, the clods of the earth, whereby the interior pores of the earth are multiplied, in proportion to the increaſe of it's ſurface; and the more numerous the pores of the earth are, the fitter it is to communicate it's nouriſhment to vegetables. But as the diviſion of the clods of the earth can be ſtill better effected mechanically, by means of the plough, than by dung,* he thinks he may from thence conclude, that *the common method of enriching land with dung is uſeleſs.*

Now it is eaſy to demonſtrate that this reaſoning is founded on three falſe hypotheſes.

a. M. DUHAMEL ſuppoſes that vegetables draw their nouriſhment from the *earth* only, or from an earthy ſubſtance; and he lays down this hypotheſis as an *axiom.* But we have evidently demonſtrated, in Chap. II. that it is contrary to the

the whole *mechaniſm of vegetables*, as well as to experience (Chap. VII. VIII.)

b. He ſuppoſes, that dung does not contribute to vegetation materially, but inſtrumentally, in producing by it's putrefaction and interior motion, the diviſion of the particles of the earth: but every one knows that this hypotheſis is contrary to experience, not to ſay farther, that one may even fertilize land with *dung which is already rotted*, and that, beſides, the motion of the putrefaction, being purely internal, does not extend to the external bodies. The anonymous author of the *Hauſh. und. Landtwiſſ.* i. e. *Oecon. & Agricult.* ſays, that dung ought to be conſidered as a *ferment*, which communicates it's motion to the earth: but he ſhould have conſidered, that matters in fermentation cannot communicate their internal motion to any other matters than ſuch as are compoſed of particles of the ſame nature, that is to ſay, *homogeneous*. Now neither the mixture, nor the diſpoſition of the particles in *mineral earth*, render it fit to receive the motion.

c. He lays down as a fact, that the dividing of the particles of the earth is equivalent to dunging: but

but both huſbandmen and gardeners know the falſity of this hypotheſis. Beſides, we have demonſtrated in the foregoing chapter, that a ſoil too much divided and too light, is not the moſt profitable, on account of the great evaporation to which it is liable *.

2*dly*. He ſays, that *dung communicates a diſagreeable taſte to plants*. He ſeems then not to have known, that the food of plants is converted, during their growth, into an analogous ſubſtance; and that putrid ſalts difficultly penetrate the pores of vegetables. This laſt truth is confirmed by COLUMELLA's experiments: for he watered a *vine* with *putrid urine*, and obſerved that neither the *grapes* nor the *wine* had contracted any bad taſte. KRAFTIUS's above-mentioned experiments prove alſo the ſame truth. As to the reſt, we muſt remark here, that it would follow from M. DUHAMEL's ſecond hypotheſis, that the juices of dung enter into vegetables, ſince theſe contract their taſte (which however is expreſsly denied in another

* I muſt, however, here refer the reader to the illuſtrious M. de CHATEAUVIEUX's Experiments, in which that opinion is abſolutely contradicted. See MILLS's *Syſtem of Practical Huſbandry*, Octavo.

place,

place, by the writers we have juſt quoted); and therefore, that it's uſe is by no means confined to the dividing of the particles of the earth.

3dly. He alledges, that *there are in dung qualities which are poiſonous and dangerous to health, becauſe it generally harbours venomous creatures.* To refute this prejudice, we anſwer, that experience proves that poiſonous vegetables planted in dung loſe much of their noxious quality, or at leaſt, that they never become more poiſonous. Beſides, it is not true that dung is of a poiſonous nature, and that there are always venomous creatures lurking in it.

4thly. He likewiſe ſays, that *dung is fit only to fill the ground with weeds, eſpecially darnel.* We anſwer, that their growth is owing *to the culture of the land*, more than to the dung that is laid on it. We grant, indeed, that the *dung of horſes* may often produce this effect, becauſe it is pretty common for horſes to void whole the ſeeds or corn which they have ſwallowed without chewing them: but the huſbandman is not ignorant that this inconvenience can be remedied *by culture alone. Cow-dung*, and the dung of other *ruminating*

animals, makes a very good manure, in which there are none of thoſe ſeeds.

5*thly*. and laſtly He maintains *that dung attracts worms and inſects to ſeeds or plants*. We partly agree with him in this: but as that multitude of worms which are in the earth depends in a great meaſure on the badneſs of the huſbandry (Chap. XIV. Sect. 6.), we think this evil may be remedied by a good culture, or by other means.

Sect. VII.

The *vegetables* generally uſed for manure are either in a *ſound*, or in a *putrefied* ſtate. Thoſe of the *former* kind, as, for example, *the leaves of the fir and pine, the bark of trees, their boughs or twigs, bits of wood, ſaw-duſt, &c.* contain, it is true, a ſubſtance analogous to that of vegetables: but as they do not rot eaſily when ſpread upon the ground, and beſides contain but very little of unctuous and watery parts, they of courſe cannot be of any laſting ſervice: from whence it evidently appears, that dung ſhould be preferred to them, as forming a better manure. They are however ſerviceable, in that they abſorb the acid of the land; though, if they are uſed in too great quantity, they communicate

municate to the earth itſelf a part of the acidity with which they are fraught. Hence ariſes the opinion of ſome, who think that the mixture of theſe kinds of vegetables renders land of a ſour or acid nature.

Sect. VIII.

We rank in the claſs of *deſtroyed* vegetables,

1. The *black mould* and *turf*, of which we treated in Chap. VIII.

2. *Soot*, of which we pointed out the nature and properties in Chap. XIV. Sect. 24.

3. *Coal-aſhes*, which many eſteem on account of their property of attracting and retaining water, and of abſorbing the acidity of the earth. However, they cannot in themſelves contribute to the nouriſhment of plants, ſince no unctuous nor ſaline ſubſtances can be extracted from them.

Sect. IX.

It is difficult to ſay preciſely *at what time land ſhould be manured*. The principal points to be attended to in this reſpect are,

1. That the land be *dry*, and thereby fit to receive and retain the unctuous parts of the manure.

2. That the manure be ſpread without delay, and diſperſed as equally as poſſible.

3. That it ſhould alſo ſpeedily be mixed with the earth, and buried at a proper depth, in order that the oily and watery particles may not fly off.

The *autumn* ſeems therefore the fitteſt time for this work, *when the earth is dry.*

SECT. X.

Too *much dung* may do hurt,

1. In a *warm and light ſoil*, by giving it a ſtill greater degree of *heat*, which in a manner burns up vegetables.

2. In a *ſtrong ſoil*, by making the plants ſhoot up too faſt, in which caſe they ſeldom ripen well: they produce larger leaves and ſtronger ſtems, but ſmaller ſeeds (Chap. III. Sect. 8. N° 3.)

The manure ſhould therefore be proportioned to the nature of the land.

SECT. XI.

That the manure may be proportioned to the land, (Sect. 10.) it is neceſſary to obſerve the following rules.

1*ſt.* The

1*ſt.* The *wetter*, and conſequently the *colder land is*, the more dung it requires; for it's cold nature ſhould be corrected by the *heat* of the dung.

2*d.* *A drier ſoil* requires leſs dung, leſt the too great heat ſhould burn the plants.

3*d.* *Clayey lands*, and thoſe which are of a ſtill colder nature, (Chap. XI.) *require a dung which is not putrefied: human ordure, the dung of fowls, of ſheep, of goats, of hogs, and of horſes*, are fitter for them than any other dung.

4*th.* *Mould*, being generally drier, (Chap. X.) does not require ſo great a quantity of dung.

5*th.* *Sandy land*, being naturally hot, (Chap. XII.) and ſuperficially covered with a layer which is ſtill more ſo, requires a putrefied dung: that which is not putrefied may alſo ſuit it, but leſs ſhould be laid on at a time, and oftener.

Remark. From what has now been ſaid concerning *the nature of lands and of dung*, whether more or leſs hot or cold, it is eaſy to judge of the *quality* and *quantity* fit for each ſoil. Of all dungs, the *human* is the hotteſt, and that of *cows* the coldeſt; the dung of *fowls* is hotter than the dung of *ſheep*; this laſt is hotter than the dung of

horſes, and ſo of others. (Sect. 1. *Rem.* I.) The dungs moſt commonly uſed, are thoſe of cows, horſes, ſheep, and hogs.

6*th*. As no dung laſts above ſix years in the ground, and after that time produces no ſenſible effect, it is neceſſary to renew the dunging of the ground every ſeventh year: but if the ſoil is ſandy, and it has been dunged with vegetable ſubſtances, (Sect. 7.) that renewal ſhould be made ſooner and oftener.

Remark. The nature of the vegetables that are mixed with the dung, as well of thoſe which yet remain found (Sect. 7.), as of thoſe which are deſtroyed (Sect. 8.), gives us eaſily to know what judgment to form of them. This circumſtance in particular ſhould be carefully attended to, namely, that the mixture of heterogeneous ſubſtances, ſuch as *lime*, *aſhes*, *&c*. rather leſſens the quality of the dung, than renders it better, eſpecially if they are mixed in too great quantity; for they conſume the unctuous parts by their corroſive nature.

CHAP.

CHAP. XVI.

OF THE MIXTURE OF EARTHS.

SECT. I.

CORN cannot grow ſucceſsfully, *unleſs the earth is duly mouldered*, on the three following accounts.

1. That the roots may the more eaſily, and without hinderance, extend themſelves.

2. That *the air may have free acceſs* to the roots (Chap. V. Sect. 14.)

3. That the food of plants, intimately connected with the particles of the earth, may with equal eaſe be every where applied to the roots (Chap. II. Sect. 5. N° 2.)

Remark I. M. DUHAMEL DU MONCEAU, in the book before quoted, has treated at large of this laſt circumſtance, as being the chief object to which our attention ſhould be turned; founded on his opinion, that vegetables draw the principal part of their

food from the earth (Chap. VII. Sect. 1, and Sect. 6. *Rem.* II.); and that therefore the duly preparing the earth is of greater utility, indeed neceſſity, than all kinds of manures. But we have already ſufficiently refuted this opinion, the fallacy of which will hereafter appear ſtill more evidently.

Remark II. They who place in the number of manures the different kinds of earths, ſuch as *clay* and *calcareous ſubſtances*, confound the effects of manures with that of mixture of earths; for want of knowing, that the plentiful crops which ariſe from ſuch mixtures, ſhould not be attributed to any matter which ſerves as food of plants, but to the looſeneſs and preparation which the earth acquires thereby.

Sect. II.

Too light a ſoil is expoſed to the various injuries of the air; for it eaſily loſes it's *rich* and watery particles by evaporation, and ſtill more readily admits heat and cold to the roots of plants, which are thereby either dried up, or chilled. *On theſe accounts*

accounts the husbandman reaps little profit from this soil. (Chap. VII. Sect. 3.)

Remark. *Gardeners* prefer a light soil, because they can prevent these injuries by watering, and other means. The *husbandman*, on the contrary, chooses a *strong* soil. (Chap. VII. Sect. 3.)

Sect. III.

Too strong and *too light soils* are each attended with inconveniencies (Sect. 1, 2.); and therefore it is necessary to observe a proportional mean in the mixture of them, on which we shall make the following observations.

1. *A strong soil to be rendered in a certain degree lighter, but yet to retain a proneness to tenacity* (Sect. 1, 2.). Hence it arises, that *the tougher and colder a clay is*, the more it stands in need of being corrected by *sand*, or *peat-earth*; and the more it abounds with *acid*, the more it will be benefited by *marle*, by *ashes of every kind*, by *lime*, or by other such like *absorbent* or *heating* substances. If it is too *moist*, the *dust of coals*, or *vegetable substances, not yet altered*, seem proper applications.

Remark. The proportions of different ſubſtances neceſſary to render ſoils of a due conſiſtence, may be determined in the following manner. Mix the ſoils in a certain proportion, add *water* to them, and if the mixture adheres too ſtrongly together when dry, then more of the light ſoil ſhould be added; and if, on the contrary, the mixture falls aſunder too eaſily, more of the binding earths ſhould be added, till the ſoil is ſuch as that it falls eaſily into ſmall bits: then it is ſaid to be a *proper ſoil.*

2. Soils which are naturally *too moiſt*, ſhould have *drying* ſubſtances added to them, as mentioned in Chap. VI. Sect. 11. and to thoſe which are *too dry*, ſhould be added *marle* or *clay*, becauſe theſe attract moiſture.

Remark. It muſt be obſerved, that as ſome plants delight in moiſture, and others in dry ſituations, regard ſhould always be had to this difference.

Sect. IV.

This mixture of ſoils may be performed *three ways*;

1. By

1. By carrying to the field the ſoil which is to be added.

2. By mixing dung with it before it is added, thereby to enrich it.

3. By digging on the ſpot for ſuch ſubſtances as are wanted, and, if found there, mixing them with the ſurface.

SECT. V.

As it is certain that earth which has been impregnated with ſome rich manure, promotes vegetation more than earth which is not ſo impregnated; it is evident that they act wiſely, who, if they can, mix dung with the earth which is to be added to the ſoil (Sect. 4. N° 2.)

Remark. Though the earth thus mixed with the dung enlarges the heap, yet we muſt not think that it adds any thing to the food of plants. This mixture may, indeed, intangle the rich particles which might otherwiſe be loſt, and ſpread them ſo as to come more at the roots.

SECT. VI.

The earth which has never been turned up, or expoſed to the action of the air, is by ſome called *barren*, by others *virgin earth*. This earth is very different in different places, being ſometimes of the ſame quality with that over it, and at other times of quite another quality. It is ſometimes *ſand* or *gravel*, and at other times *clay* or *marle*; conſequently ſometimes *better*, and at other times *worſe*, than the mould which covers it. Judgment is therefore neceſſary in determining whether it ſhould be plowed up. In general we may conclude, that *the richer or better quality it is of, and the deeper it goes, the more profitable it will be to raiſe it to the ſurface by deep plowing, and to mix it with the upper mould.*

Remark. Philoſophers have differed much in their opinions of this earth. HOFFMAN, and more particularly JOHN FRED. NEUMAN, in his book intitled *von dem Kornbau*, and alſo in his treatiſe *von der wilde Erde*, *&c.* (i. e. on un-tamed land), were of opinion that this earth is abſolutely *barren*, and that it is always prejudicial to raiſe it to the ſurface,

face. In ſupport of this, they quote an example mentioned in DENS's *Monatliche Beyträge*, (Monthly Guide) p. 181. of a man who rendered a field barren by raiſing ſand to the ſurface. They alſo alledge, that none of the manure mixed with the ſoil reaches this earth, but that it rather aſcends into the air or plants. J. A. HERTZOG, in *Oecon. Nachr.* (Accounts of Economical Improvements), Vol. II. p. 18. N° 1. and J. G. ORTHIUS, in Vol. II. p. 18 and 19. of the ſame work, are of a contrary opinion, and declare that they have not only ſeen fields which have been plowed deeper than ordinary yield plentiful crops without manure; but alſo that poor ſoils, on which new earth has been ſpread, have proved more fruitful, and continued ſo, than if they had been manured. DE LA QUINTINIC, in his *Inſtruction for Gardens*, P. 2. Chap. IV. Sect. 2. and PETER KRETZSCHMER, in *Oecon. Pract.* with many others, agree in opinion that it is of great ſervice to *trench* ground.

The

The better to ſhew what judgment ſhould be formed on this ſubject, it is proper to lay down the following rules.

1*ſt.* If the virgin earth does not exceed the ſurface in goodneſs, or is not at leaſt equal to it, the beſt way is to let it remain untouched.

2*d.* If this layer of earth is not above half a yard deep, it ſhould be ſparingly diſplaced, however good it may be; for if the layer is broke through, the goodneſs of the manures may be loſt by it's ſinking into the ſoil below.

3*d.* We agree with NEUMAN, that heat draws the rich exhalations out of the earth: but he has ſurely forgot, that the richneſs conveyed into the earth may be carried down by the rain or ſnow-water, if a paſſage is afforded to it; and on that account ſuch paſſage ſhould not be made. If *ſand* or *gravel* lies underneath, they ſhould not be touched.

4*th.* It is to be obſerved, that this virgin earth may have in it ſo ſtrong a *mineral acid*, as to be prejudicial to vegetables (Chap. VI. Sect. 8.); and that it cannot be rendered looſe by ſlight or few plowings. It muſt therefore be frequently turned, in order that, all it's parts being expoſed to the air, it's hurtful particles may be carried off, and it may be impregnated with whatever it may receive

receive from the air. Thus, earth which is very *barren* when firſt turned up, becomes afterwards very fruitful; becauſe it attracts the contents of the air more ſtrongly than earth which has been long expoſed to it. On this principle, the benefit of *trenching* may be fully underſtood.

CHAP.

CHAP. XVII.

OF PLOWING, OF SOWING, AND OF CULTIVATING THE EARTH.

SECT. I.

WE need not repeat the reaſons already aſſigned for *frequently ſtirring the earth*; (Chap. V. Sect. 8. and Chap. XVI. Sect. 1.) but muſt add, that, in uncultivated land, graſſes and many other weeds grow, which conſume the food of uſeful plants, and by binding the earth with their numerous fibrous roots, render it hard and compact: likewiſe, that water lying long in the crevices of the earth, contracts an *acid* which is prejudicial to corn. Theſe inconveniencies render *plowing* neceſſary;

1*ſt*. In order *to expoſe every part of the earth to the influence of the air.*

2*dly*. *To diſſipate the hurtful acid.*

3*dly*. *To extirpate the roots of all weeds.*

4*thly*. *To render the earth looſe, by thoroughly mixing with it the manures of any kind laid on it.*

Remark.

Remark. It may be ſaid, that *drains* will rid the earth of the acid complained of. This is true ſo far as the acid depends on ſtagnating water: but there is a mineral acid combined ſometimes ſo cloſely with the earth, that nothing will take it off, but this expoſure to the air.

SECT. II.

It appears from what has been ſaid (Sect. 1.), that *light looſe* ſoils do not require to be ſo often plowed as *ſtrong tough* ones (Chap. XVI. Sect. 2.)

Remark. M. DUHAMEL DU MONCEAU has juſtly obſerved (*Traité de la Culture des Terres*, Tom. I. p. 57.) that frequent plowing even of light ſoils renders the earth more equally looſe; becauſe the finer particles may have been waſhed away, and thereby many crevices left in it.

SECT. III.

As it is not our intention here to enter into the mechanical principles of agriculture, or deſcriptions of inſtruments, we ſhall only mention the chief

chief reaſons on which plowing is founded. Theſe may be reduced to the following rules:

1*ſt. The more an acid abounds in the ſoil, and the fuller it is of weeds, the more the earth requires to be ſtirred,* for reaſons before aſſigned.

2*d. Special care ſhould be taken not to leave any baulks, or earth unlooſened between the furrows.* This may eaſily be diſcovered by running a ſtick into the earth, and trying whether it is every where of an equal depth. It may alſo be known by the plough's going conſtantly in a ſtraight line; for wherever it varies, a baulk muſt be left.

3*d. The firſt plowing ſhould be given in the uſual direction of the field,* becauſe the earth will riſe the more eaſily that way, owing to the former furrows.

4*th. The ſecond plowing ſhould be given in an oblique direction to the former,* or *at an acute angle,* that the clods may be the more broken.

5*th. The third plowing ſhould be acroſs the firſt,* the more effectually to break the clods by this new direction.

Harrows, rollers, &c. are uſed, to break the clods ſtill ſmaller, as well as to drag out the roots of weeds.

SECT.

SECT. IV.

As to the *time of plowing*, it may be eſtabliſhed as a general rule, *to plow when the earth is moſt eaſily divided*; for otherwiſe we ſhould loſe our object (Sect. I.) Hence it follows, that

1*ſt. The earth ſhould not be plowed when it is wet*, becauſe it will then turn over in large clods, which, in drought, will bake into hard lumps, eſpecially if it be a ſtrong ſoil.

2*dly. A moiſt ſoil ſhould be plowed in a dry ſeaſon*, in order the better to carry off the water.

3*dly. Light ſoils may admit of plowing in dripping ſeaſons.*

SECT. V.

The deepneſs of the furrows ſhould be proportioned to the depth to which the roots of the plants cultivated are known to extend, (for the reaſons aſſigned in Chap. VI. Sect. 14.) Going deeper is *uſeleſs*, if not *hurtful*, by draining away the richneſs of the ſuperincumbent earth (Chap. XVI. Sect. 6. *Rem.* II.).

Remark. This queſtion has of late been greatly agitated: many, upon the ſtrength of WOLFIUS's

FIUS's afore-mentioned experiments (Chap. III. Sect. 2.), being of opinion that the plowing ſhould be as deep as poſſible, in order that the roots may not only deſcend the lower, but alſo branch out the more in ſearch of greater plenty of food. It is for this reaſon that KRETZSCHMER thinks land ſhould be *trenched* (Chap. XVI. Sect. 6. *Rem.*) Others, obſerving that corn fallen by chance on the ground grows and thrives, conclude from thence, that deep plowing is not neceſſary. We ſhall make the following obſervations on this ſubject.

1*ſt. All ſoils have not the ſame depth*, and conſequently ſhould be plowed accordingly, as before ſaid (Chap. XVI. Sect. 6. *Rem.* II.).

2*dly. The depth ſhould be proportioned to the length of the roots*, which being different in different plants, they conſequently require different depths of mould, into which the air, rain, &c. may have admiſſion.

3*dly. The depth of the plowing may alſo be proportioned to the depth at which the ſeed*

is laid in the earth; on which it is proper to ſay a few words.

SECT. VI.

The *ends* propoſed by covering the ſeed, are,

1*ſt*. To ſhelter it from birds, inſects, and other animals.

2*dly*. To protect it from the injuries of the air: for droughts might harden it too much, and rain might waſh away the rich mould neceſſary for bringing forward it's germination.

3*dly*. To enable the ſeed, by giving it a proper place, to ſhoot out roots and ſtem; for it is known by experiment, that no ſeed germinates if it is buried ſo deep as to be out of the reach of the influences of the air. TULL and DUHAMEL have ſhewn, that ſeeds which have been covered with a depth of nine inches of earth, have remained without any change for ten years; that ſome have grown at the depth of ſix inches, and others better at only one or two. C. DAHLMAN ESKILLSON has repeated nearly the ſame experiments.

Here

Hence we may conclude, that *no ſeeds ſhould be buried deeper than ſix inches, whilſt three or leſs will be ſufficient for others.*

SECT. VII.

With regard to *the quantity of ſeed*, it ſhould be regulated according to the nature of the plant and quality of the ſoil: for,

1*ſt. The richer the ſoil is, and the better order it is in, the thinner the ſeed ſhould be ſown*; becauſe, in this caſe, the plants tiller the more, and thereby fill the ground the more; they alſo become ſtronger, are better able to keep upright, and to ripen a greater quantity of ſeed. On the contrary, if ſown too thick, the plants are weak, eaſily laid, and ripen few ſeeds.

2*dly. The poorer the ſoil is, the thicker the ſeed ſhould be ſown*; becauſe here the plants tiller leſs.

SECT. VIII.

The time of ſowing is generally regulated by the quality of the ſoil, by the ſeaſon, and by other circumſtances: but without entering into theſe, we ſhall only conſider the *autumnal* and the *ſpring* ſowing.

The

The *autumnal* ſowing may be regulated by *the ripening of the ſeed*, which nature in general points out as the ſeaſon for ſowing the ſeeds of plants that are *natives* of the climate.

Remark. When, however, the ſummers have been wet and cold, the wheat may ripen ſo late, that it will be prudent to ſow old ſeed the earlier: for if the ſeed is ſown too late, it does not take ſufficient root to ſtand the winter's froſt and winds.

The *time* for ſowing in *ſpring* cannot be preciſely determined, becauſe it muſt depend on the *quality and condition of the land*, which ſhould neither be wet nor too dry, but in a looſe ſtate. A judicious farmer will manage matters accordingly.

SECT. IX.

The methods of covering the ſeed with the plough or *harrow* are ſo well known, that it would be needleſs to ſay any thing of them here. On a declivity, the *ſeed-furrows* ſhould be made acroſs the declivity, with only a gentle deſcent, leſt

leſt heavy rains ſhould carry off the finer mould. Each furrow is by this means a drain to the ridge underneath.

SECT. X.

In order that the ſtem of the plant may riſe the more eaſily, the incumbent earth ſhould be in a looſe ſtate; for if the young leaves cannot pierce through the *cruſt* of the ſoil, they there die or rot. That *cruſt* ſhould therefore, if formed, be broke with harrows or ploughs, before the ſowing.

SECT. XI.

So ſoon as the leaves have pierced the ſurface, it's looſeneſs is no longer of ſo great conſequence: perhaps it's being then even compact, may prevent the effects of drought. It is at leaſt a frequent practice to *roll* land after the plants are come up, by ſome with this view, and by others to ſmooth the ſurface, eſpecially where the crop is to be mowed. Alſo, the firſt leaves being by this means bruiſed, the plants may perhaps be brought to tiller the more.

Remark,

Remark. As we conſider agriculture here only in a chemical light, we ſhall not enter into deſcriptions of mechanical inſtruments made uſe of in it.

CHAP.

CHAP. XVIII.

OF THE MEANS OF REMOVING CERTAIN OBSTACLES WITH REGARD TO THE EARTH.

SECT. I.

THE principal *inconveniencies* which weaken plants, or prevent their receiving a due ſhare of nouriſhment (Chap. II. Sect. 5. N° 4.), and which may be removed by the induſtry of men, are, *woods*, *water*, *rocks* and *ſtones*, or *animals*, which may become hurtful. We ſhall now briefly conſider each of theſe.

SECT. II.

Trees hurt by their ſhade and roots, which ſhould never come near a field of corn. Moiſture and ſnow lie longer in woods than elſewhere, and thereby chill the air.

Remark. A wiſe huſbandman will however conſider whether wood or corn is moſt profitable, and chooſe accordingly.

Sect. III.

Every tree or ſhrub in a field ſhould be rooted up, in order to turn the ground they ſtand on to better purpoſe, and prevent the inconveniencies of their ſhade and leaves, which ſmother other plants, as well as ſour the ground.

Sect. IV.

In order to prevent the inconveniencies of *too much water* (Chap. VI. Sect. 11.), *drains* ſhould be made to carry it off.

Where there is a *declivity* in the field, theſe *drains ſhould have a very gentle deſcent*, leſt the water, by a quick current, ſhould hollow the earth, and make itſelf new channels.

The moiſter and flatter a wet field is, the more in number and the larger the drains ſhould be. In every caſe, they ſhould be proportioned to the quantity of water to be diſcharged, the *ſmaller* opening into *larger*. Even *hollow drains* ſhould be made as near the ſurface as plowing will admit of, that ſo the water in them may ſoak into the earth, and nouriſh the roots of plants.

SECT. V.

Special care ſhould be taken *that the drains be of an equal depth*, that water may no where *ſtand and putrefy*; and that, in corn-fields, furrows be made to carry the water every where into the ditches.

Remark. Theſe precautions are peculiarly neceſſary where quantities of ſnow melt in the ſpring, or the place is ſubject to inundations.

SECT. VI.

Snow is hurtful:

1*ſt*. When it falls on earth not yet frozen; becauſe it prevents the froſt's penetrating into the ground to a ſufficient depth, to hinder the plants from being waſhed away when the ſnow melts.

2*dly*. When it melts ſuddenly in ſpring, and thereby renders the land too wet.

3*dly*. By forming drifts or great depths of ſnow againſt hedges or trees, or in hollows, from which it ſhould be diſcharged; as is done in northern climates, where they have ploughs for that purpoſe.

SECT.

SECT. VII.

Rocks and large stones are hurtful, by the cold shade they cast, and by the coldness of frost, *and collection of snow* (Sect 6.), which last longer around them than elsewhere. Large stones should therefore be blown up and removed, and rocks as much as possible. *Small stones* have, in general, been thought to be beneficial.

SECT. VIII.

Plants can be preserved from *animals* only by *fences*, *traps*, and *poisons*, adapted to the nature of each. *Frequent good tilth* is the best preservative from *noxious insects*, which are thereby prevented from hatching their young.

We now conclude with the saying of CATO, to which succeeding ages have given the sanction of an Oracle.—*What is the first thing requisite in husbandry? To keep the land in good order. What the next? To plow it well. What the third? To dung it. Plow not*, adds he, *at different depths: plow seasonably. The direction of the first furrows should*

ſhould be length-ways of the field, and the next oblique *.

* *Quid eſt primum? agrum bene colere. Quid ſecundum? bene arare. Quid tertium? ſtercorare. Sulco vario ne ares; tempeſtive ares. Omne arvum rectis ſulcis, mox obliquis* †, *ſubigi debit.* PLIN. Nat. Hiſt. Lib. XVIII. c. 9.

† By directing *oblique* furrows for the laſt plowing, this excellent huſbandman would ſeem to intend, not only more thoroughly to break the clods of the earth, but alſo to correct any inequality that might have been in the firſt plowing.

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